INTERNATIONAL CONCILIATION

Published monthly, except July and August, by the
Carnegie Endowment for International Peace

Entered as second-class matter September 15, 1924, at the post office at
Worcester, Massachusetts, under the Act of March 3, 1879.

CHEMICAL WARFARE—
ITS POSSIBILITIES AND PROBABILITIES

By

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MARCH, 1929

No. 248

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE
DIVISION OF INTERCOURSE AND EDUCATION
PUBLICATION OFFICE: 44 PORTLAND STREET, WORCESTER, MASS.
EDITORIAL OFFICE: 405 WEST 117TH STREET, NEW YORK CITY

Subscription price: 25 cents for one year, one dollar for five years
Single copies 5 cents

PREFACE

The following document has been prepared by Mrs. Elvira K. Fradkin of Montclair, New Jersey, who has made a careful study of the whole problem of chemical warfare. As will be seen from the appended bibliography, publications on the subject are not lacking, but Mrs. Fradkin's document is so far as we can learn the only available publication which treats the whole subject including the history of its development, its technical side, and its international significance. A glance at the table of contents will show how comprehensively this has been done.

Mrs. Fradkin received her A.B. degree from Vassar College and her M.A. degree from Columbia University. She has devoted a great deal of time to the study of international questions and as will be seen from her introduction feels that the problem of chemical warfare is such that the facts should be known to the general public and frankly faced.

NICHOLAS MURRAY BUTLER

New York, February 1, 1929.

CHEMICAL WARFARE—ITS POSSIBILITIES AND PROBABILITIES

By

Elvira K. Fradkin, M.A.

Introduction

Those of you who will read this pamphlet through, will—if this is your first experience with the facts concerning chemical warfare—feel the urge to "do something about it." Those of us who have taken on our shoulders the responsibility of telling the truth about chemical warfare, feel the same urge. Military and Naval tacticians conversant with the seriousness of the situation, as it is here revealed, agree that "something must be done." The chiefs of the chemical services know better than anyone else what is in store for us—if there should be another conflict—and they, too, feel that the public should know the facts.

Sometimes the desire to abolish lethal gases and poison smokes, on the basis of these facts, is misinterpreted. Each passing year makes that desire more keen and more determined. It is not that, because the Germans violated treaty obligations in first liberating chlorine, that poison gas should be abolished. It is not, as an author insists, that, as gas is a new weapon, it should be abolished. It is not that one might think poison gas is barbarous and inhumane. Despite these and other reasons, which I have read more than once, the reader of this pamphlet will, at the end, agree with the writer that there is a much more fundamental objection to the continued use of poison gases than these above mentioned. This objection is self-revelatory as the facts unfold and is the mainspring behind the desire and determination that chemical warfare, as it is bound up with all warfare, must cease.

From the vantage point of a non-combatant, this conclusion is arrived at with more impartiality, a bit more clarity and, surely, with more evident desire. For we, the non-combatants in the future conflict, are to be wiped off the map. The distinction, in warfare, between combatant and non-combatant has—due to the increasing

range of gunfire and the use of poison gas—been practically obliterated, just as other principles of fairness and the minimum of decency in warfare, slowly built up through the ages, have all been obliterated. This is a very dangerous fact. Judge John Bassett Moore, the first American Judge on the World Court declares, in his book, *International Law and Some Current Illusions:*

> Prior to the recent great conflict, whose magnitude and momentous importance render exaggeration superfluous, the development of the laws of war, running through a number of centuries, had been in the direction of establishing and extending the following fundamental principles:
>
> 1. The observance of the distinction between combatants and non-combatants and the protection of non-combatants against injuries not incidental to military operations against combatants.
>
> 2. The protection of property not militarily used or in immediate likelihood of being so used against destruction, not, as writers sometimes seem to fancy, because of humane regard for insensate things, but because of the belief that, in the interest of humanity, war-stricken peoples should not be reduced to a condition of barbarism or savagery, but should, on the contrary, be enabled to resume the normal processes of peaceful life as soon as possible.
>
> 3. The abolition, for similar reasons, of the confiscation of private property, except so far as for special reasons it is still permitted at sea.
>
> 4. The definite assurance to states, not parties to the conflict, of the right to continue their commerce with one another, and, subject to prescribed limitations, also with the warring powers.
>
> During and since the recent war all these principles, painfully achieved through centuries of conflict, have to a great extent been questioned. This has been done on the supposition that the recent war, in its drafts on the population, the resources and the activities of the countries involved, was unlike any previous war; that, in contributing to the conduct of the war, all work, in a sense unknown before, became war work and all the inhabitants war workers, the unarmed population no less than the military forces; that the distinction between combatants and non-combatants consequently lost its meaning and ceased to be ascertainable; and that, as the recent war is to be taken as the type of future wars, the distinction between combatants and non-combatants and the rules deduced from it, having lost their validity, can no longer be respected.

> I do not hesitate to declare this supposition, both in its assumptions of fact and of principle and in its implications, to be as illusory as it is dangerous.
>
> I pronounce it dangerous, because the distinction between combatants and non-combatants is the foundation and the vital source of those limitations on the destruction of life and property with which our boasted civilization is synonymous. I pronounce it illusory, because it proceeds from a misconception not only of the nature and extent of previous wars but also of the grounds on which the unarmed population was classed as non-combatant and protected.

However, whether we like it or not, the new far-cruising airplane bombers, carrying a bomb load of 9,000 pounds, with its crew of six and mountings for ten machine guns will bring death and destruction to a wide area and, amid the roar of anti-aircraft guns, will not be able to choose military objectives for targets. A whole city will be the target, and with the combination of high explosive and lingering poison gas, the target can and will be obliterated. Hence, the interest of the non-combatant as well as the combatant in the subject of poison gas. When it is realized, further, that, in the future, all shells, from the 75mm. up, will carry some form of poison gas (General Fries' statement), our interest widens and deepens.

It is an interesting fact that the words "poison gas" are not truly descriptive. In the shot or shell, cylinder or projector, the gas is not gas at all but in either liquid or solid form. The ballistic engineer in the ammunition factories determines the proportionate amount of poison gas and explosive. As the war progressed, the proportion of poison gas increased and the number of shells, carrying the lethal fluid or solid, increased. Only, upon expulsion from the container, does the liquid volatilize into a gaseous state or the solid, transformed by the heat of the explosion, become a poison gas. With the exception of phosgene, which is a colorless gas at 80 F. (normal pressure), this is true of almost all the gases in use during the last war. However, the words "poison gas," to include poisonous smokes, have received such wide popular usage that, to avoid confusion, they will be used in this essay for irritant and lethal gases with the above limitations understood.

The author is deeply indebted to the excellent and patient efforts of the librarians in the Montclair Free Public Library, to Mrs. Carrie Chapman Catt for her inspiration and unwavering faith,

and to the Carnegie Endowment for International Peace for the opportunity to publish the pamphlet.

ELVIRA K. FRADKIN.

THE HISTORY OF CHEMICAL WARFARE (BEFORE THE WORLD WAR)

Although the term "poison gas" is so new that one cannot find it in the dictionary, its use in warfare can be traced back many hundreds of years. Twenty-three hundred years ago when the city of Platæa was besieged by the Spartans in 429 B.C., the attacking troops placed enormous pots of pitch, sulphur, and burning charcoal against the walls so that the irritating gases from this mixture would reach the beleaguered fighters and annoy them. A century later, Aeneas the Tactician, spoke of using pitch and sulphur in the Peloponnesian war. He also noted that an inextinguishable fire may be created by the combination of pitch, sulphur, tow, granulated frankincense, and pine sawdust in sacks. This was called Greek fire. Another expert (Groot) says that it contained sulphur, naptha, wax, oil of balm, quicklime.

Emperor Leo VI spoke of the value of this Greek fire and also advised throwing jars of quicklime on the enemy's ships to suffocate him. In the historical annals of Genoa, describing a war fought between that city and Pisa in 1284, we find "a bitter and hard fight began from both sides. In it so many missiles containing lime and other alkalies were used that it seemed as though none were present" meaning that their eyes were so irritated, they could not see. It is interesting to quote a description of a battle fought in 1456 between the Turks and the inhabitants of the beleaguered city of Belgrade, led by Hunyadi and St. John Capristan:

> Late in the afternoon, July 21, 1456, the Turks hurled themselves against their prey. They filled the moat with straw, rubbish and brushwood, gained a passage and stormed the broken walls. The Moslems set up an attack so terrific that they broke their way into the city as far as the second wall and moat. There the Christians held them fast. The Turks brought up more rubbish and brushwood and filled the second moat. Then they sought to scale the walls. Although the Christians' defence was vigorous, the odds in men and position were in favor of the enemy. But suddenly, at a prearranged signal, the Christians began hurling down upon the massed forces of the enemy bundles of burning sulphur-steeped brush-

wood. The effect was swift and decisive. The rubbish-filled moat became a pool of raging fire. Caught between the wall and the moat, the Turks perished by thousands in the flames and the fumes. The survivors became panic-stricken and fled.

In the Middle Ages, gas stink bombs were known and used. Even the Chinese and Malay pirates had a form of chemical warfare in their stink pots. An old Austrian chemist, Vlit Wulff von Senfftenberg, in 1573, said of these stink bombs: "It is a terrible thing. Christians should not use it against Christians, but they may be used against the Turks and other unbelievers to harm them."

Then, the value in warfare of smokes, which screen the movements of troops, was recognized. Gustavus Adolphus of Sweden in 1631, learned from his adversary, Tilly, the value of great quantities of smoke in hiding the location of troops. He used this knowledge in the following spring when by the judicious placing of burning straw, the resulting smoke hid the building of a bridge over the Lech River, near Augsburg, and thus enabled his soldiers to cross unknown to the enemy and overwhelm him. In 1699, his successor—Charles XII—used the same strategy against the Saxon troops and successfully crossed the Dvina River. In a quarter of an hour he was on the other side. He had his guns immediately disembarked and formed line of battle before his enemies, their vision obscured by smoke, could oppose him.

Indeed, the tendency to use in warfare what chemical knowledge at the time could supply, was, with one exception, the irresistible tendency of military leaders. This one exception is of such immediate interest that it will be reviewed. The first definite suggestion in modern warfare for the use of sulphur fumes to subdue a stronghold, was made by the English Lord Dundonald in 1885. During the Crimean War, he suggested that, with favorable wind conditions, the fumes from burning sulphur would be wafted toward the beleaguered city of Sebastopol. Its effect, he prophesied to the conference of interested military leaders, would be instantaneous and highly deleterious to the Russians. Due consideration was given the idea by the Generals on the field and the War ministry at home. However, the suggestion was finally rejected on the score of its inhumanity—"for it was felt that an operation of this nature would contravene the laws of civilized warfare." The investigating committees who had examined these proposals of Lord Dundonald's

and pronounced that "the effects were so horrible that no honorable combatant could use the means required to produce them"—also ordered the memoranda destroyed. However, in the tiresome memoirs of Lord Panmure who was consulted by the British Government on this intended usage of sulphur fumes, there was found, upon publication in 1908, the whole scheme as outlined by Lord Dundonald. This was read, supposedly, by German chemists and improved upon during the World War.

From this time on (1885) to the opening of hostilities coincident with the World War, there occurred a steady expansion in the chemical industry which now deserves close scrutiny because of its direct bearing on the correlated result—chemical warfare.

A Short History of Chemical Expansion (1880–1914)

The publications concerning various gases, as they were discovered in connection with the developing chemical industry, were first made in Germany, as it was there that the chemical industry got a running start. In 1880, two German chemists, La Coste and Michaelis published *Uber Aromatische Arsenverbindungen* (*Concerning Aromatic Arsenic Compounds*). In 1881, La Coste published in the *Annalen der Chemie und Pharmazie*, "Uber Benzarsensauren und deren Derivate"; in 1886, Victor Meyer, a noted chemist, wrote and published "Uber Thiodiglykolverbindungen" in the *Berichte der Deutschen Chemischen Gesellschaft* and Lehmann, another noted research worker published the following articles in the *Archiv für Hygiene:* "Experimentelle Studien uber den Einfluss technisch und hygienisch wichtiger Gase und Dampfe auf den Organismus," "Ammoniak und Salzaure Gas (Experimental Studies Concerning the Effect of Technical and Hygienically Important Gases on the Organism," "Ammonia and Hydrochloric Acid Gas). In 1887, appeared his study "Chlor und Brom" (Chlorine and Bromine), in 1892, "Schwefelwasserstoff" (Sulphurated Hydrogen); in 1894, "Schwefelkohlenstoff und Chlorschwefel" (Carbon Disulphide and Chlorinated Sulphur); in 1903, his interest in poison gas and its effects on man and beast takes form in the following article: "Neue Untersuchungen uber die quantitative Absorption einiger giftiger Gase von Tier und Mensch durch den Respirationstraktus und seine Teile" (New Investigations Concerning the Quantitative Absorption of Some Poison Gases in the Respiration Tracts of the Animals and Man).

These researches were developing in Germany, where each step forward in the fight against poison gases in the chemical manufacturing industries was applied to the protection and guidance of workers in those industries. A similar need for research and protection was noticed in the British mining industry, at home and in South Africa. The experience of such a well-known English chemist as J. B. S. Haldane in evolving protective measures for the British mine workers was invaluable when the gas warfare started in 1915. His publications, from 1895 on, were directed toward the alleviation of mine workers from mine gases. In 1895 appeared *The Action of Carbonic Oxide on Man.* In 1896, *The Report to the Secretary of State for the Home Department on the Causes of Death in Colliery Explosions and Underground Fires.* In 1896, *Poisoning by Gas in Sewers.* In 1905, Macaulay published in the *Transvaal Medical Journal*, "Gassing by Dynamite Fumes," etc.

These titles are neither exhaustive nor do they afford an adequate idea of the scope within the country, or in other countries, of the developing experience with poison gases in peace-time industries. They are indicative of the movement which has gathered volume with each passing year, to apply the experiences of chemists and industrialists to the problems of chemical warfare.

That this interrelation and application has been eminently successful, is proven by the following figures. As, generally speaking, the same apparatus, machinery and factories which make dyes, perfumes and medicines, were used by Germany and the Allies to produce poison gas, figures on these production standards are illuminating. "Germany in 1918 produced 135,000 tons of dye stuffs annually as compared with a total production of 86,000 tons by all the rest of the non-Teutonic world." (Vedder *Medical Aspects of Chemical Warfare*). However, the war demands for poison gas expanded the factories in all countries. In 1916 the British output of warfare gas was 5,150 tons; in 1917, 18,500 tons and for ten months of 1918, 15,500 tons (Vedder). The monthly capacity at the Armistice of the American Edgewood Arsenal, which represents a master feat in rapid organization and construction (ground was broken and construction started November 15, 1917) totalled in November 1918:

Titanium tetrachloride	30 tons
Tin tetrachloride	90 "
White phosphorus	100 "
Mustard Gas	900 "
Bromobenzyl cyanide	90 "
Phosgene	1050 "
Chloropicrin	1500 "
Gaseous chlorine	1500 "
Liquid chlorine	895 "

This monthly output did not include the contributions from some of our chemical factories. Great Britain and France were, also, bending every energy to produce enough gases and smokes to enable their troops to take the gas offensive. Except for the limited experiences—as typified by the titles of the afore-mentioned chemical publications—the Allied and Associated powers, unprepared and in the midst of a terrific war, had to readjust and develop from the bottom up, gas factories, mask factories, transportation, and repair departments. In a word, a chemical service was hammered out from the beginning. They called on the expanding chemical factories and research chemists for help.

This intensive and extensive expansion in the whole field of chemical industry merits our attention only in so far as it affects the status of chemical warfare. From the preceding pages, it is abundantly evident that without this industrial and chemical development, chemical warfare as such, would have been an impossible achievement in the World War. Indeed a German chemist declares that, on the basis of historical development of chemical warfare, coupled with the development of chemical and dye industry before the war, it was an inevitable conclusion that the nation, so fortunately placed as to include a great chemical industry within its territory, would be forced, in self-protection, to resort to the use of poison gases, despite international agreements. This vital point will be discussed in detail in the last chapter. Here, the emphasis must be placed on the international agreements limiting the use of poison gases, which were contracted before the World War.

The Hague Conventions (1899 and 1907)

Keenly aware of the inherent dangers connected with this chemical expansion even before the World War, the diplomats assembled for

the first Hague conference, called together in 1899 by the Czar of Russia, carefully discussed the implications and finally evolved, in the naval committee, the following convention which was submitted to the representatives from the twenty-seven participating nations and signed by all but two, Great Britain and the United States abstaining.

Declaration IV Concerning Asphyxiating Gases.

The undersigned, plenipotentiaries of the powers represented at the International Peace Conference at the Hague duly authorized to that effect by their governments—

Inspired by the sentiments which found expression in the declaration of St. Petersburg of November 29 (December 11) 1868,

Declare that:

The contracting powers agree to abstain from the use of projectiles, the sole object of which is the diffusion of asphyxiating or deleterious gases.

The present declaration is only binding on the contracting powers in the case of war between two or more of them.

It shall cease to be binding from the time when in a war between the contracting powers, one of the belligerents shall be joined by a non-contracting power.

The present declaration shall be ratified as soon as possible.

The ratifications shall be deposited at the Hague. A procès-verbal shall be drawn up upon the receipt of each ratification, a copy of which duly certified shall be sent through the diplomatic channel to all contracting powers.

The non-signatory powers may adhere to the present declaration. For the purpose, they must make their adhesion known to the contracting powers by means of a written notification addressed to the Netherland Government, and by it communicated to all the other contracting powers.

In the event of one of the high contracting powers denouncing the present declaration, such denunciation shall not take effect until a year after the notification made in writing to the Government of the Netherlands, and by it forthwith communicated to all the other contracting powers.

This denunciation shall have effect only in regard to the notifying power.

In faith of which the plenipotentiaries have signed the present declaration and have affixed their seals thereto.

Done at the Hague July 29, 1899 in a single original which shall remain deposited in the archives of the Netherland Government and copies of which, duly certified, shall be sent through the diplomatic channel to the contracting powers.

This convention was ratified by Austria-Hungary, Belgium, Bulgaria, China, Denmark, France, Germany, Greece, Italy, Japan, Luxembourg, Mexico, Montenegro, Netherlands, Norway, Persia, Portugal, Roumania, Russia, Serbia, Siam, Spain, Sweden, Switzerland, Turkey.

Our American representative on this committee, Captain Mahan, gave the following reasons for his refusal to sign the convention, forbidding the use of asphyxiating gases. "The distinguished representative of the United States of America on the naval subcommittee gave the following reasons for voting against the provision (the poison gas convention) and they were inserted in the report of the proceedings of the committee: 1. That no shell emitting such gases is as yet in practical use or has undergone adequate experiment, consequently, a vote taken now would be taken in ignorance of the facts as to whether injury in excess of that necessary to attain the end of warfare, of immediately disabling the enemy, would be inflicted. 2. That the reproach of cruelty and perfidy addressed against those supposed shells was equally uttered formerly against fire arms and torpedoes, although each are now employed without scruple. Until we know the effects of such asphyxiating shells, there was no saying whether they would be more or less merciful than missiles now permitted. 3. That it was illogical and not demonstrably humane to be tender about asphyxiating men with gas, when all were prepared to admit that it was allowable to blow the bottom out of an ironclad at midnight throwing four or five hundred men into the sea to be choked up by water, with scarcely the remotest chance of escape. If and when a shell emitting asphyxiating gases has been successfully produced, then and not before will men be able to vote intelligently on the subject."

For his day and age, the cautious Captain, later to become Admiral Mahan, a great authority on Far Eastern questions, registered his opposition fairly and squarely. But the wiser diplomats, knowing more intimately the sinister development and expansion in the chemical industries in some countries and its probable effect on warfare, voted again to prohibit "the discharge of projectiles and explosives from balloons or by other new methods of a similar nature," at the second Hague Conference in 1907, called together by President Roosevelt.

The 1907 Hague declaration reads as follows:

The undersigned, plenipotentiaries of the powers invited to the Second International Peace Conference at The Hague, duly authorized to that effect by their governments.

Inspired by the sentiments which found expression in the declaration of St. Petersburg of the 29th November (11 December), 1868, and being desirous of renewing the declaration of The Hague of the 29th July, 1899, which has now expired.

Declare:

The contracting powers agree to prohibit, for a period extending to the close of the Third Peace Conference, the discharge of projectiles and explosives from balloons or by other new methods of a similar nature.

The present declaration is only binding from the time when, in a war between the contracting powers, one of the belligerents is joined by a non-contracting power.

The present declaration shall be ratified as soon as possible.

The ratifications shall be deposited at The Hague.

A procès-verbal shall be drawn up recording the receipt of the ratifications, of which a duly certified copy shall be sent, through the diplomatic channel, to all the contracting powers.

Non-signatory powers may adhere to the present declaration. To do so, they must make known their adhesion to the contracting powers by means of a written notification, addressed to the Netherland Government, and communicated by it to all the contracting powers.

In the event of one of the high contracting parties denouncing the present declaration, such denunciation shall not take effect until a year after the notification made in writing to the Netherland Government, and forthwith communicated by it to all the other contracting powers.

This denunciation shall only have effect in regard to the notifying power.

In faith whereof the plenipotentiaries have appended their signatures to the present declaration.

Done at The Hague, the 18th October, 1907, in a single copy, which shall remain deposited in the archives of the Netherland Government, and duly certified copies of which shall be sent, through the diplomatic channel, to the contracting powers.

Thereto should be included Article 23 of the 1907 rules adopted for war on land which states:

In addition to the prohibitions provided by special conventions, it is especially forbidden:

a. To employ poison or poisoned weapons;

b. To kill or wound treacherously individuals belonging to the hostile nation or army;

c. To kill or wound an enemy who, having laid down his arms, or having no longer means of defense, has surrendered at discretion;

d. To declare that no quarter will be given;

e. To employ arms, projectiles, or materials calculated to cause unnecessary suffering;

f. To make improper use of a flag of truce, of the national flag, or of the military insignia and uniform of the enemy, as well as the distinctive badges of the Geneva Convention;

g. To destroy or seize the enemy's property, unless such destruction or seizure be imperatively demanded by the necessities of war;

h. To declare abolished, suspended, or inadmissable in a court of law the rights and actions of the nationals of the hostile party.

Subdivision (a) definitely limits the use of poison gas and subdivision (e) is supposed to protect the unmasked soldier. Neither were effective when war broke out. In fact, when one reads these Hague resolutions and the various subdivisions, when one contemplates the great ceremony with which they were signed and even ratified, one is convinced that the human race had only achieved the first gesture toward sincere disarmament and only the faint beginnings in that complicated psychology of international understanding and mutual trust between nations.

Looking back on The Hague conferences of 1899 and 1907, with the rather cynical perspective of the World War to blot out this fractional achievement of the human race, the conviction gathers strength that all future progress along the path of international cooperation depends in the final analysis, upon the peoples of the world. The diplomats and intelligentsia in the different countries realized the perilously rocky road which modern nations had embarked upon before the war, with increasing armaments mounting yearly into staggering totals. Crowned Heads, warned by their far-seeing statesmen, called Hague conferences. But, judging by the revelations which are brought to light in the successive research studies on the World War, the cataclysm was inevitable because the machinery for war was itching to be used. Kings, warning statesmen, Hague conventions, were powerless before this onrush of a malevolent psychological reaction. International honor, international morality, even that very fundamental of all fundamentals—the individual's self-respect upon which rests truth, decency, trust,

chivalry, honor, and the complicated human reactions built upon these fundamentals—all, all were swept away. Statesmen will always be powerless unless the people are awakened. Backed up by the demands of an intelligent home public opinion, great strides may be taken forward toward that ultimate goal—an absolutely necessary goal if we and our children are to survive—gradual, sincere, effective universal disarmament. Forewarned by the results of chemical warfare in the last war, as well as by the developing possibilities which will be noted as this study progresses, clear instructions must be given the statesmen, based upon a clear knowledge of the actual facts, so that chemical disarmament will be truly achieved. Unless these dictates are made universally binding, the next conflict will be more terrible and more widespread than the last.

But, before the contemplation of the chemical warfare of the future engrosses our attention too closely, it is the wiser policy to review first the use of poison gas and smokes in the last war.

History of Poison Gas (During the World War)

The first clouds of chlorine gas were released on the afternoon of April 22, 1915 by the Germans and carried by a favoring wind toward the Allied lines, which were holding on to the northeast part of the Ypres salient where the French and British lines met, and then running southward from where the trenches left the canal near Boesinghe. The French right was held by a regiment of Turcos and the British left was held by the Canadians. Auld[1] describes the attack as follows: "Try to imagine the feelings and the condition of the colored troops as they saw the vast cloud of greenish-yellow gas spring out of the ground and slowly move down wind towards them, the vapor clinging to the earth, seeking out every hole and hollow and filling the trenches and shell holes as it came. First wonder, then fear; then, as the first fringes of the cloud enveloped them and left them choking and agonized in the fight for breath—panic. Those who could move, broke and ran, trying, generally in vain, to outstrip the cloud which followed inexorably after them."

This gas release actually was not the first which the Germans had attempted. It is recorded by one of their leading chemists[2] and an army officer, that a previous attempt at gas warfare had been made

[1] Auld, *Gas and Flame.*
[2] Julius Meyer, *Chemische Kampfstoffe.*

on the Eastern front but because they did not know how to use weather conditions to the advantage of the attack, the result was death to the German soldiers who were experimenting with the new device. So new and unaccountable was the first attack of gas warfare on the Western front that the Germans themselves had no inkling of its devastating success. Death, terror, and disorganization cleared the path to that much-desired goal—the channel ports. The General in Chief of the American Chemical Warfare Section, General Amos A. Fries, has said "had the German High Command known the real situation at the close of the first gas attack, or had that attack been more severe, the outcome of the war of 1914 would have been very different, and the end very much earlier."

But such are the inscrutable laws of human nature. The advantage was not sufficiently followed up, the Allied lines closed the gap and the channel ports were saved. Chemical warfare was an established fact despite international agreements. The Allies and the Entente had to immediately cope with it, and the race started (it has never stopped) to develop its possibilities to the fullest extent. In reading the various reports, both chemical and diplomatic, concerning the origins of gas warfare, the statement is made generally by the Germans that the Germans had forestalled a contemplated French gas attack. In the light of the whole history of the World War, as it is revealed to us by each succeeding document, the truth of this charge and the innumerable counter-charges which it inevitably brings up, is immaterial to the fact. We have noted, in previous pages, the great expansion in the chemical industry, and its effect on military and diplomatic international commitments (the Hague conventions). Both of these factors will play an exceedingly important part in future conflicts. A third factor, equally true in the last war and as true for all future wars, is the desperate psychology of a chemical-producing nation pressed for its very life existence by encircling foes. Facing these facts of past and factors of future warfare, there is only one conclusion to be drawn, a conclusion made more clear and irresistible as we continue with the history of poison gas in the World War.

It is interesting to note that in this first attack, chlorine gas was used because it represented the easily obtainable product of the great chemical industries in Germany. Chlorine is a by-product of the dye and bleaching factories and furnishes the fundamental

basis for many of the newer mixtures of poisonous gases. In strong concentrations, it acts as a lethal gas as well as a sensory irritant. This first attack, under ideal weather conditions and in strong concentration, had a strong lethal effect on the unprotected troops. Chlorine is one of the ideal poison gases because it is highly toxic; it is readily manufactured in large quantities; it is easily compressed into liquid form and then as easily volatilized when exploding from shells, bombs, or as in the case of this first attack, from cylinders; its density is higher than air, hence it settles in valleys and depressions (cellars, dug-outs, houses, etc.); it is stable against moisture; it is two and a half times as heavy as air and therefore the gas is capable of traveling over a considerable distance before it dissipates into the atmosphere. These commendable qualities recommend its use as a basic toxic gas. The chemical industry can, does, and will furnish great quantities of chlorine gas in future conflicts. Such raw materials, necessary in the manufacture of poison gases as salt, bleach, picric-acid, alcohol, sulfur, sulfur chloride, bromine, etc., were and can be obtained from commercial firms. For all available resources were commandeered by both sides in the struggle to furnish poison gas and to fill the cylinders and shells, projectors and bombs with lethal gas.

Just a word is necessary here concerning the different methods of gas dispersal. The first attack with poison gas was made by cylinder dispersal. The Germans laboriously hauled to the front line trenches huge cylinders and long hose attachments. The mechanical difficulties and the possibility of detection by airplanes as well as the fact that only chlorine and phosgene can be so dispersed, has led to the curtailment of this form of gas dispersal. Then, too, a strong concentration of gas by this means was difficult of attainment. Weather conditions played an important factor, unfavorable, particularly to the Germans' offensive, as the prevailing winds blew in Northern France from West to East. Hence, other forms of gas dispersal were evolved—such as the Stokes mortar, an English invention, with a range of about 800 to 1000 yards, and a gas-filled shell (15 shots per minute) emitted from a specially constructed gun. There was the Livens projector, another British invention for gas dispersal. Bombs, containing usually phosgene, were exploded from these nickel steel tube projectors which were lined up 100 or more at a time and their explosions timed by connecting them in

series with ordinary blasting machines operated by hand from a convenient point in the rear. Hand grenades were used. The German flammenwerfer was at first successful, too.

However, for dependable action, regardless of weather conditions, and for the desired concentration strength, nothing could or did supersede the gas-filled artillery shell and the airplane bomb. For these both have the valuable asset of movability as well as long distance ranges. According to the latest military ideas, all shells fired by the artillery will contain gas. This broad statement includes shells of all sizes, from those discharged from the 75mm. gun to the very largest in use. "It is even possible that if guns smaller than the 75mm. become generally useful, that certain gases will be fired by them." (Fries). Hence, we know that "the battlefield of the future will be saturated with gas." (General de Feuville.) The gas may be increased in artillery shell to the desired extent of fifty per cent of the total weight, as is the case in bombs. These latter as well as the huge shell which the big Berthas of the future will train on distant targets may, with their fifty per cent poison gas be dropped into the large cities and under favorable weather conditions achieve a very efficient concentration of lethal gas on totally unprotected populations. The airplane gas bomb has even greater possibilities inasmuch as it has to be only strong enough to withstand the low pressure of the gas and ordinary handling, while the artillery shell must be strong enough to withstand the shock of discharge of the gun. There is still one further method of dispersing gas, which will find great favor in the future. The sprinkling of poison gases from airplanes is a simple, efficient method, obviating costly guns and shells.

Mustard gas (dichlorethylsulfide) is particularly suited to this mode of dispersal because it is heavier than air, persistent, lethal and irritant and above all virtues, it has delayed action, so that no effect is felt until five or six hours after exposure. So the increased exposure proportionately works greater havoc. Sprinkling from airplanes of persistent gases around crossroads, railroad yards, concentration points, and encampments as well as in crowded centers of population, insures the success of the attacking troops for persistent gases may remain a source of contamination and danger for days, if not weeks. The airplane will play a vital part in the gas warfare of the future and as its range increases, so directly the danger to all combatants

and non-combatants increases. By sprinkling, by bombs, by bullets, by shells, and every other conceivable device, poison gas will be rained upon humanity within reach. Concentrations of any desired strength may be achieved by the well-trained chemical service officer.

If, for instance, he is firing non-persistent agents from the artillery, a concentrated fire should be used with the center of impact slightly up wind from the target. The fire should be repeated every one hundred yards in depth, if effect is desired behind the front line. Concentrations for lachrymatory and persistent gases can be built up in small or large areas by distributing the number of bursts. Surprise chemical attacks must combine quick work with the highest consonant marksmanship. The detail of the number of shots per minute per area has been carefully worked out for the different size guns to produce such results as the following: 1. to deny ground to the enemy and secure casualties by getting liquid mustard in contact with the individual (the efficiency of the denial increases with the number of infected spots); 2. to secure lung casualties and produce casualties by covering an area with persistent and non-persistent lethal gas thoroughly. The whole question of concentrations of poison gases is the province of the chemical warfare officer who has been trained to take advantage of every favoring factor and utilize every circumstance. It is a mathematical science.

The aviator, too, is an adept at this science as well as the knowledge of weather conditions, so that his preparation is directly in line with chemical warfare. Indeed, the airplane will, as it rapidly develops, become one of the main methods for the dispersal of poison gas and smokes. The connection between aviation and chemical warfare is so close that in one country, a new word has been coined to signify this relationship, "Avio-chemistry." Chief in the probable implications of this term is the connection between civil and military aviation. Some of the improvements to modern airplanes are aimed not only toward increased safety but also towards increasing the adaptability for war emergencies. In discussing the report on airplanes of the Washington Conference on the Limitation of Armament, Dr. Royse in his book *Aerial Bombardment* says: "The development of commercial aeronautics and the development of a nation's air power are inseparable. . . . The characteristics essential to a military aircraft could also be profitably incorporated into commercial machines. Such qualities as carrying

capacity, speed, altitude capacity, radius-of-action, and the capacity for offensive and defensive equipment, so requisite for military aircraft, were not altogether foreign to commercial aircraft, and in many types of craft were more inclined to be identical with the needs of the commercial aircraft." Because of this close interrelationship, it was found, then, impossible to regulate or limit airplanes. A British jurist, E. G. deMontmorency in *The Washington Conference and the Air-Law in Disarmament* says: "The advance of science has transformed, or will within a brief period transform, warfare in such a fashion as to make the experiences of 1914–1918 mere child's play. The public do not realize at all the significance of November 11, 1918, in respect to air warfare. It was only beginning to become really terrible towards the end of the late war. "The pursuit, the bomber, the observation, and the attack planes of today are machines as superior in every way to those that were the 'eyes' of Foch and Pershing and Haig, as the radio of today is superior to the wireless of a quarter of a century ago." (*A Mighty Air Force Now Roars Skywards*, L. C. Speers). Reducing the engine noise, increasing the speed of the plane by eliminating wires and other friction-producing projections, as well as developing the horse power of the engines; camouflage paint which reduces the visibility of a plane, either against the sky in the day-time or in searchlight rays at night; radio connection between planes and between the plane and a ground station; improved noise detectors, etc., show the intimate connection that exists between airplane improvements and the air war of the future. Brigadier General Lord Thomson, late Air Minister in the British Government, predicts, from the vantage point of intimate knowledge, "the next war will be fought in the air, it will consist of aeroplane raids above the great cities, and the primary attack will be against civilians, including women and children. Against these, incendiary, explosive and poison gas bombs will be used. No defense that has yet been devised will prevent the death of thousands of persons in any city thus attacked, and the organized life of any great metropolitan center would be brought to a standstill for days or weeks."

To understand clearly the modern trend in international competition for increasing numbers of airplanes and the ever-constant connection, in the case of an international conflict, between the civilian or commercial airplanes and their military usages, it is of

interest to quote the following excerpt from the *Journal of the United States Cavalry Association:*

The modern airplane with its fragmentation bombs and machine guns, is a factor that must receive attention. The huge gas bombs filled with lethal agents must be considered. However, I believe that the greatest menace of all is the hostile plane spraying liquid mustard. There is no practical method of protection against liquid mustard at the present date. Liquid mustard penetrates all clothing, rubber and leather, and burns all skin with which it comes in contact. The burns are hard to heal and prone to infection. Its vapor is more poisonous than the vapor of hydrocyanic acid. Liquid mustard will persist on the ground, grass and underbrush from several days to several weeks.

The hostile planes, equipped with mustard tanks and flying low, can release the liquid mustard on its target. This method of projection of vesicant (or blister-making) agents would enable enemy planes to infect large areas and cover large targets within a few seconds, and cover so effectively that practically every man and animal would be a certain casualty within a few hours. This would also be the case of any personnel of animals entering, passing through, or occupying the infected area.

A recent test of this method with simulated mustard showed 600,000 drops of the agent on the standing figure of a man fifty yards down wind from the point of release. Ample drops of this liquid to cause casualties covered other targets extending to 400 yards distant from the point of release. These planes fly from 100 to 300 feet from the ground and at a speed approaching 200 miles an hour.

Another feature of the attack is that a plane precedes the real attack, covering the target with smoke, which enables the other planes to attack with but little danger from anti-aircraft fire from the columns or bivouacs.

We may imagine what may be expected of the air force in another war. Bombers capable of carrying great loads of high explosives and capable of flying high and fast will be able to penetrate to centres of production and create tremendous damage, provided sufficient fighting planes are available to destroy the enemy fighters and thus enable these bombers to carry on. The operation of bombers, observation planes, high altitude photographic planes and 'ground strafing' attack planes is greatly dependent upon availability of fighting planes.

The whole thing comes back to the supremacy of the air.

It will not be even safe to have troops march at night. Observation planes with brilliant flares will seek them out and low flying attack planes will spray them with bullets, bombs and

poisonous gases. This does not mean that the Air Force can fight or win a war alone but it does mean that if the enemy has an Air Force of any strength, its Air Force must be neutralized before the ground units can operate to any extent at all.

This neutralization process means annihilation for combatants and non-combatants in the fighting zone. A great military expert sums up the situation tersely in these words: "That is just a sample of what is coming on every field of battle—gas used on both sides by every method of putting it over that can be devised."

Since the Wright brothers proved the feasibility of man-carrying heavier-than-air machines by their historic flight, December 17, 1903, the succeeding twenty-five years have marked tremendous steps forward in the development of the airplane. Transoceanic and transcontinental flights have been successfully negotiated. Regular mail and passenger air routes are established in the United States, Europe, South America. The extension of these air lines to include all continents and all countries is only a matter of a short time. The world is air-minded and from this attitude may arise all that is good for friendly international relations, or all that is evil. In addressing the International Conference on Aviation, held at Washington, December 12–17, 1928, President Coolidge ended his speech in these prophetic words: "All nations are looking forward to the day of extensive, regular, and reasonably safe intercontinental and interoceanic transportation by airplane and airship. What the future holds out even the imagination may be inadequate to grasp. We may be sure, however, that the perfection and extension of air transport throughout the world will be of the utmost significance to civilization. While the primary aim of this industry is and will be commercial and economic and the prosperity of the world will be immeasurably advanced by it, indirectly but no less surely, will the nations be drawn more closely together in bonds of amity and understanding. This conference, I know, will have far-reaching results in the advancement of science and industry which appeals both to the spirit and reason of man, and which as the years go by will cement more and more firmly the bonds of international brotherhood." This is the hope of every thoughtful observer of airplane development. Can we and will we restrict that development to the friendly mission?

The development of the dirigible has been equally sensational and pregnant with possibilities which "even the imagination may be

inadequate to grasp." The Navy department of the United States has concentrated its main interest in the development of the dirigible although the airplane carriers are assuming an important place. The Navy's interest in the interrelationship between the expanding chemical warfare and its methods of dispersal must naturally be very intense. The problem of poison gas and its effect on battleship construction and personnel has been carefully studied. The explosion of a few H.E. lethal gas bombs over the largest warship renders that ship, costing many millions, utterly useless. Beside the calculated effect of the high explosive, the lethal gas, thus liberated, will be sucked through the ventilation system of the ship and reach, on its deadly errand, every man aboard. In the midst of a terrific bombardment, when every man aboard is working with steady concentration, who knows when he is in the presence of an odorless, persistent lethal gas? If the ship survives the explosive bombardment, in a few hours it and all the men aboard will be useless and shunned by possible rescuers. Casualties and deaths will affect every man.

Gas-filled bombs will be dropped on the enemy from dirigibles, from airplanes launched by the carriers or from the warship's decks. There are other means which the Navy has devised to disperse poison gas and smokes. To quote from Lieutenant Commander Duncan C. Walton's chapter on "Naval Aspects of Chemical Warfare" in Vedder's book *The Medical Aspects of Chemical Warfare:*

Poison gas may be dispersed from:

1. Boxes and cylinders.

a. To be used from aboard ship. Many types of these boxes were used during the World War for simple screening operations. They could easily be adapted to the release of toxic materials in clouds.

b. Floating smoke boxes. These were thrown overboard for screening purposes during the World War and were found to be of great value. If filled with toxic materials and released to windward of the enemy they should be effective.

c. Toxic smokes could be mixed with the ordinary screening smoke from the funnels as appears to have been done in the German attack on H. M. S. Botha.

2. Torpedoes.

a. It is very doubtful if gas would be ever used in torpedoes fired for a direct hit.

b. The use of broaching torpedoes which would generate a cloud of toxic materials in the midst of the enemy fleet has been suggested.

3. Mines. The filling of marine mines with chemical agents offers little of value as an offensive weapon.

4. Shells. Probably none of the large calibre naval shells will ever be filled exclusively with chemical agents. But the use of a shell similar to the German blue cross shell (diphenylchloroarsine or other sternutators) which contained a small bottle of toxic smoke embedded in the high explosive filling, or the inclusion in shells of a small amount of lachrymatory substance would produce many gas casualties and compel the enemy to mask in addition to the usual demolition effect. (It is the feeling of most military and naval authorities that all shells will contain some poison gas. Commander Walton previously stated, "A general review of the above would indicate that practically all gases used at sea would be of a persistent nature and only those which act rapidly on the organism would be used during an engagement.")

5. Aircraft. Gases can be projected on vessels by any of the following means:

a. Sprays of persistent agents.

b. Curtains and screens of immediate irritants during an engagement.

c. By the dropping of float bombs to windward; such bombs can distil off a cloud of gas or smoke for from five to fifteen minutes.

d. Direct hits by bombs filled with persistent agents.

e. The sprinkling, with slowly hydrolizable compounds, of harbors or of places where landing forces are to be feared.

Thus the Navy is vitally concerned with the whole question of chemical warfare. Cognizant of the future possibilities, the General Board of the Navy reported in 1921 to Secretary Hughes: "The General Board believes it to be sound policy to prohibit gas warfare in every form against every objective, and so recommends."

Gases known and unknown will torture the men aboard ships. As sea power consists of naval armament and merchant marine, the possibilities for the dissemination of poison gases from and to other ships is a field rich in unexplored tactics.

Then, too, the use of smokes by the Navy as well as the Army will afford another field where ingenuity can have full play if based on knowledge of materials and weather conditions. Smokes were used

in two distinct ways. As a defensive screen, day and night, smokes were invaluable and it can, also, especially if mixed with poison gas, attack the enemy troops and ships. "In the Navy, smoke screens laid down by smaller ships, give the larger ships a chance to maneuver for position and range. These screens were also established for the purpose of cutting off the view of the enemy submarines or other vessels, thus allowing merchant ships or even warships, when injured or outclassed, to escape." It was soon found, during the war, that white phosphorus, a solid which could be dispersed from artillery shells, bombs, Stokes mortar shells, grenades, and candles was the most efficient for the purpose. White phosphorus will keep on burning when the individual non-atomized lumps fall on the ground or on flesh. Hence, it fulfills the double action of a good screening and an excellent agent for producing casualties and terror. "Heavy bursts of white phosphorus from Stokes mortars not only blot out observation but produce serious casualties from the burning phosphorus as well as a terrorizing effect." (Army Manual.) The value of smoke is now being fully appreciated in the chemical warfare of the future. "Every smoke cloud will be poisonous or non-poisonous at the will of the one producing the cloud, and this will be true whether it is produced from artillery shell, mortar bombs, hand grenades, smoke candles or other apparatus." (Fries). If this uncertainty as to the probable content of a smoke cloud is extended to cover its use "on every field of battle, by every arm of the service and at all times of day and night," one can visualize the conflict of the future in no uncertain terms. An airplane of the type of the Martin bomber can lay a smoke curtain about 1600 yards long. How many airplanes are needed to completely isolate a city whose circumference is so and so many yards with an effective poison gas smoke screen while the enemy planes of the big bombing type drop H. E. lethal gas bombs? It reminds one of the arithmetic examples of the days of our youth. Smoke may also be used to mask concentrations of poison gas, or to cover construction work undertaken in the face of the enemy, or to upset the enemy fire by placing smoke screens directly in his vision, or to cover river crossings etc. Other smoke-producing chemicals such as sulphur trioxide, oleum, titanium tetrachloride and zinc chloride have their uses. All can be combined with poison gases so that, whether so mixed or not, the wearing of the gas mask is the better part of wisdom. The varieties in the

mixtures and in the possibilities for surprise are so obvious that the smoke cloud of the future will be thoroughly distrusted. When dispersed together with an unknown poison gas, the mask is easily penetrated. Army and Navy officials, foreseeing these possibilities, have made known their objections to chemical warfare at international conferences. This measured stand is taken with full knowledge of the facts concerning smokes and irritant and lethal gases.

What kinds of poison gases have been used and will be used to so move the conservative as well as thoroughly alert Naval Board, experts in offensive and defensive warfare, to its condemnation?

As has been noted, chlorine was first liberated by the Germans on April 22, 1915. The Allies decided in May, 1915, that retaliation in kind was inevitable, and on September 25, 1915, the first English gas attack was launched. However, it was the Germans who, because of advanced chemical and industrial development at home, could take the initiative in gas warfare in the field. Hence, as protection against existing gases was developed by the Allies, they, the Germans, took the lead in introducing new gases. Thus, after chlorine had been successfully tried, lachrymators or tear gases were employed to harrass the enemy. Lachrymators such as xylyl bromide, the French mixture called martonite (80% bromoacetone and 20% chloroacetone), the British contribution of ethyl iodoacetate, the German chlorobenzene, or, too, bromomethylethylketone, were all effective. Two other tear gases, which were not perfected in time for war usage, have proven their worth and will be extensively used, if necessity warrants—bromobenzyl cyanide C_6H_5CH (BR) CN and chloroacetophenone. These lachrymators are dispersed by hand grenades, artillery shell, trench mortar bombs, Stokes mortars, light minenwerfer, and projectors and sometimes, cylinders.

It must be borne in mind that other lethal or lung irritant gases may also have a lachrymatory action. It all depends on the concentration of the gas. For instance, chloropicrin is both lethal in strong concentration and lachrymatory in mild concentrations. Mixtures of gases may accomplish both results at the same time, for instance, chlorine (70%) and chloropicrin (30%) fired together from cylinders has a lachrymatory and lethal action. The advantage in these mixtures lies in the fact that a sensory irritant gas will so disturb the enemy that, upon removing his gas mask, the lethal gas will take effect. These mixtures are a long study in themselves. Their

worth was recognized in 1916 and from then on, constantly developed. Still, only a beginning was made in their possibilities. Such combinations as hydrocyanic acid (55%), chloroform (25%) and arsenious chloride (20%) are specially effective lethal agents which, dispersed from artillery shell, can achieve strong concentrations. These mixtures accomplish another much-to-be-desired aim. An unusual or unknown mixture of poison gases can penetrate any gas mask, not designed to meet this particular onslaught and so render protection by that means impossible. However, this phase will be discussed later when the general subject of protection is discussed. The art of mixing irritant and lethal gases is very important and very exacting. Wind, weather, temperature, moisture, all are consulting factors. Then, the objective to be attained must be considered and the most effective mixture for that purpose, decided upon at short notice. The work of the Chemical Warfare Service Officer is increasingly important and as new poison gases are being put at his disposal, increasingly difficult. The problem of a successful poison gas bombardment involves not only the annihilation of the enemy but also protection of ones own attacking troops as they enter the gas-filled territory. All branches of the army will use gas: the infantry will use poison gas in the rifle, grenade, and toxic smoke candles; the cavalry will use gas in the Stokes mortars which are mobile; tanks will use gas which they can easily carry with them and disperse as they proceed; the artillery will use gas in every shot and shell, long range into distant cities and short range into the enemy trenches; the air service will use gas bombs, as has been outlined above; the Navy will use gas in all its various branches. The chemical officer of the future will be all-important and all-powerful.

Consider the poison gases in the following table which he had at his command during the last war and then consider that "the use of gas in that war was a child's game compared to what it will be in the future." (Fries).

CHEMICAL WARFARE GASES

Chemical	Belligerent	Effect	Means of Projection
acrolein (allyladehyde)	French	lachrymatory lethal	hand grenades
arsenic chloride			
benzyl chloride	French	lachrymatory	artillery shell
benzyl iodide	French	lachrymatory	artillery shell

Chemical	Belligerent	Effect	Means of Projection
bromoacetone	French	lachrymatory lethal	artillery shell
bromobenzyl cyanide	French	lachrymatory	artillery shell
bromomethylethylketone	German	lachrymatory lethal	artillery shell
benzyl bromide	German French	lachrymatory	artillery shell
chlorine	German British French American	lethal	cylinders (cloud gas)
chlorosulfonic acid	German	irritant	hand grenades light minenwerfer
chloroacetone	French	lachrymatory	artillery shell
chlorobenzene (as solvent)	German	lachrymatory	artillery shell
chloropicrin	British French German American	lethal lachrymatory	artillery shells trench mortar bombs projectors
cyanogen bromide	Austrian	lethal	artillery shell
dichlormethylether (as solvent)	German	lachrymatory	artillery shell
diphenylchloroarsine	German	sternutatory lethal	artillery shell
dichlorethylsulfide	German French British American	vesicant lethal irritant	artillery shell
ethyldichloroarsine	German	lethal	artillery shell
ethyliodoacetate	British	lachrymatory	artillery shell, 4 inch Stokes mortars, hand grenades
hydrocyanic acid	French	in mixtures	
methylchlorosulfonate	German	irritant	minenwerfer
monochloromethyl-chloroformate	French German	lethal	artillery shell
phosgene	British French German American	lethal	projectors, trench mortars, artillery shell, cylinders
phenylcarbylamine chloride	German	lachrymatory irritant	artillery shell
trichloromethyl-chloroformate	German	lethal	artillery shell
stannic chloride	British French American	irritant cloud forming	hand grenades artillery, projectors, 4-inch Stokes mortars
sulfuric anhydride	German	irritant	hand granades, minenwerfer artillery shell
xylyl bromide	German	lachrymatory	artillery shell

MIXTURES OF WAR GASES

bromoacetone (80%) chloroacetone (20%)	French	lachrymatory lethal	artillery shell
chlorine (50%) phosgene (50%)	British German	lethal	cylinders
chlorine (70%) chloropicrin (30%)	British	lethal lachrymatory	cylinders

chloropicrin (65%) hydrogen sulfide (35%)	British	lethal lachrymatory	cylinders
chloropicrin (75%) stannic chloride (25%)	British French American	lethal lachrymatory irritant	artillery shell trench mortar bombs projectors
chloropicrin (75%) phosgene (25%)	British	lethal lachrymatory	artillery shell trench mortar bombs projectors
dichloroethylsulfide (80%) chlorbenzene (20%)	German French British American	vesicant lethal	artillery shell
ethyl carbazol (50%) diphenylcyanoarsine (50%)	German	sternutatory lethal	artillery shell
ethyldichlorarsine (80%) dichloromethylether (20%)	German	lethal lachrymatory	artillery shell
ethyliodoacetate (75%) alcohol (25%)	British	lachrymatory	artillery shell
hydrocyanic acid (55%) chloroform (25%) arsenious chloride (20%)	British	lethal	artillery shell
hydrocyanic acid (50%) arsenious chloride (30%) stannic chloride (15%) chloroform (5%)	French	lethal	artillery shell
phosgene (50%) arsenious chloride (50%)	British	lethal	artillery shell
dichlorethylsulfide (80%) carbon tetrachloride (20%)	German French British American	vesicant lethal	artillery shell
phosgene (60%) stannic chloride (40%)	British French	lethal irritant	artillery shell
methyl sulfate (75%) chloromethyl sulfate (25%)	French	irritant lachrymatory	artillery shell

(In the mixtures, the percentages indicate proportions by weight.)
(From *Chemical Warfare*, Fries and West.)

Many of this formidable list of poison gases were found too expensive to manufacture, some did not produce the effects which were desired and hence were abandoned and again, others were developed to take their places. All poison gases are graded into two classes: 1. the non-persistent gases, that is, gases which, upon dispersal, quickly mingle with the air and lose their effectiveness; 2. persistent gases, that is, gases which, upon dispersal, linger for hours or even days with continued strength and effectiveness. In the first class, which was evolved first in the history of poison gas, may be found the sensory irritant gases, such as lachrymators, sternutators, vomiting gases and lung irritant gases, such as, chloropicrin, phosgene, chlorine, etc. In the second class, may be found mustard gas (dichlorethylsulfide).

As one observes the development of poison gas usage in the World War, one fact becomes ominously clear. Non-persistent gases were used first. From April 1915 to July 1917, is roughly the period,

representing non-persistent gas. Although these gases are sensory irritant gases, in strong concentrations, almost all are lethal. But from July 12, 1917 when the Germans first liberated mustard gas at Ypres, until the end of the war, the tendency to use the most destructive gas was manifest. The war divided into periods of poison gas development, with overlapping times for overlapping uses, seem to fall roughly into the following categories:

April and May, 1915—six attacks with chlorine gas.
May 1915 to July 1916—lachrymators.
December 1915 to August 1916—chlorine and phosgene.
July 1916 to July 1917—phosgene, diphosgene, chloropicrin, lachrymators.
July 1917 to November 1918—gas mixtures, as represented in the German blue cross shell, green cross, K-shell, yellow cross, etc.

That this tendency toward the use of lethal poison gas is a well established fact is finally proven by the press despatch of December 15, 1928 which announces that a new poison has been discovered, more deadly than any heretofore known. Dr. Hilton Ira Jones, who announced it in Chicago says of this new poison gas, "It is a deadly poison and would destroy armies as a man might snuff out a candle. I do not believe the nations of the world want to use it for warfare, simply because it always kills. War, if it comes again and is to be deadly, will never again be fought with shot and shell. It can't be, for it is so much cheaper to destroy life wholesale with this new gas. It may be manufactured at the rate of thousands of tons a day and it costs much less than powder and cannon, yet it will destroy armies more thoroughly, more effectively, more quickly." Dr. Jones called it *cacodyl isocyanide.*

Other gases will be discovered with other more revolting properties. Although the study of the pathology of poison gases used during the war reveals body reactions which have caused in some cases death and in other cases temporary withdrawal from the battlefield, the actual effects of gassing on the human system—as revealed by animal experiments—have been the subject of constant research since the close of the war. These war gases had properties which developed serious lesions in some cases and, in all cases, broke down the natural opposition of the body to extraneous invasion of germs so that the secondary invasion of organisms which are common to the area affected, cause serious and often fatal results.

Pathology of Poison Gases

For the sake of a simple, quick grasp of this difficult and still experimentally incomplete subject of the pathology of poison gases, all gas cases may be divided into three classes: 1. slight cases, suffering from the effects of lachrymators and sneezing gas; 2. early acute cases which have had a good dose of a powerful lung irritant; 3. late acute cases which, because of the retarded action of mustard gas, develop pathological symptoms, after many hours and even after many days from the time of exposure.

In the first class, it is interesting to note that in a concentration as slight as one part in five million, effective lachrymatory action is secured. This is true of the lachrymator, ethyliodoacetate. Some sneezing gases demand a slightly stronger concentration to be effective. For instance, ethyldichlorarsine in a concentration of one part in 500,000 develops not only the sneezing habit but also pain in the throat, jaws, eyes, and head. Another sternutator, diphenylchloroarsine $(C_6H_5)_2AsCl$ causes severe burning sensations in the nose, throat, and lungs in concentrations as slight as one part in ten million. In higher concentrations, one part in 200,000 up to 500,000, it causes severe vomiting. In equal concentrations with phosgene, it is even more lethal. As these sensory irritant gases are all non-persistent, the annoying effects pass off as the gas disappears. Diphenylchlorarsine is a particulate gas, that is—a gas which upon explosion, is atomized into very fine particles. A special adjustment of the gas mask had to be made to meet this new form of gas when it was first liberated in the summer of 1917. These sensory irritant gases will always be used, not only to annoy and thus incapacitate the men in the artillery as well as in the infantry, but also in mixtures so that in desperation the gas mask must be removed, and the lethal gas may do its work. The use of these sensory irritant gases in peace times—to quell mobs and disperse cannibal hordes—is hotly argued, for and against. It is unnecessary to enter the arena here. As is always the case, the compromise action will triumph. The time, place, physical and psychological conditions must first be studied. On that basis only, is action permitted.

The second group of poison gas cases, the early acute cases which have had a good dose of a powerful lung irritant, show pathological changes of a more severe nature than those cases suffering from the sensory irritant gases, just studied. The powerful lung irritant

gases to be considered—those most often used during the last war—are phosgene, chloropicrin, chlorine, diphosgene, trichlormethyl-chloroformate, all lethal non-persistent gases. Animal experiments show that, in concentrations of one part to 4,000–5,000, phosgene is lethal. Seventy per cent of the goats observed in an experiment conducted since the war by British medical officers and reported in the *British Medical History* died when exposed to chloropicrin in a concentration of one part to 8,500–10,000. Rabbits, exposed to phosgene for thirty minutes, in concentration of one part in 32,000 died. These are the first scientific data on the length of exposure and the necessary concentrations to cause lethal action. During the war, it was a case of guesswork for there was little time for quiet research when the enemy were shelling with new poison gases. Experience was the only teacher and judging by statistics was sometimes ignored.

These pulmonary irritant gases cause death within the first forty-eight hours. There is present in the gassed patient an extreme degree of pulmonary edema (congestion in the lungs due to the presence of fluid) and the greater part of the respiratory area is out of action as a result of the presence of fluid in the alveolar spaces. With a pathological condition of this nature, it is to be supposed that death is due to curtailment of the supply of oxygen to the arterial blood. This supposition is confirmed by the analysis of the blood of gassed animals which show a very low oxygen saturation. In other words, the gassed person who has been exposed to a lethal dose of a lung irritant gas, has had the respiratory tract thoroughly burned out and is, thus, suffocated to death. This is also true of the sensory irritant gas, diphenylchloroarsine, which, when administered pure and in strong concentrations, causes complete destruction and desquamation of the epithelial lining of the air passages with resulting exudation of lymph which coagulated and prevented the passage of air. Pulmonary edema proves that the inhaled poisons which had produced these effects in the trachea and bronchi, also reached the ultimate recesses of the lungs.

Medical science has developed, necessarily, some methods by which the gassed patient can be, in some cases, relieved and cured. French and German doctors think highly of the beneficent effects of bleeding the patient after poisoning from chloropicrin or phosgene. Venesection seems to dilute the viscosity of the blood, relieve the

edema in the lungs, and help the blood circulation. The constant inflow of oxygen in cyanosed cases has helped. Experiments, since the war, are being conducted to investigate further alleviation of suffering in gas poisoning cases as well as the prevention of possible permanent impairment.

The after effects of lung irritant gas cases have not been definitely established. Chemical warfare was so utterly a new experience to the army that the pressure of adjustment prevented careful statistics and accurate follow-up work. Then, too, individuals were found to react differently to the same amount of gas. Some were more susceptible, others less susceptible. Many cases, upon recuperation, and the close of the war disappeared into the great stream of humanity. Others were gassed and wounded; some were gassed and captured; or gassed, wounded, and captured. Statistics are, hence, based only on observable cases and are admittedly inadequate. Post-war experiments on animals are seldom applicable to man as concerns the difficult question of after effects. After effects from lung irritant gases may be briefly classed as: 1. the heart cases, (medical statistics as to ultimate recovery are inadequate); 2. mentally depressed cases (with no statistics as to recurrence); 3. shallow breathing cases; 4. eye affections; 5. general debility. Those who recover from a severe case of lung irritant gas poisoning never forget the experience. There is still to be found the war veteran of any nationality who rejoices in his gassing experience. Hardened men of the world have actually wept when the least association with this poison gas experience has been brought to mind. They will tell you of the terrors of nightmares, as they relive in their dreams the terrors of the battlefield, drenched with gas. To us, the non-combatants, it is a waking nightmare.

The third group of cases—those late acute cases which, because of the retarded action of mustard gas, develop pathological symptoms after many hours and even after many days from the time of exposure—represent a very large group. It has been said that from its introduction by the Germans on July 12, 1917, mustard gas casualties were greater than the combined casualties of the previous years' shelling. It was the introduction of the first and so far, the only practicable persistent poison gas which has revolutionized the science of warfare and awakened the conscience of the world to its possibilities for combatant and non-combatant torture.

Mustard gas $(ClCH_2CH_2)_2S$ in the pure state is a colorless liquid with a boiling point of 220° C. and a freezing point of 11° C. It is called the "king of poison gases" because: 1. in strong concentrations, it is highly lethal (death may occur even up to the fourteenth day after exposure); 2. in liquid form as well as in the vapor, which the exploded shells scatter in all directions, mustard gas inflicts body burns, seeking out the moist parts first; 3. it penetrates all clothing, rubber and leather; 4. food or drink, exposed to the vapor or liquid, is contaminated and if consumed, causes severe gastric and intestinal symptoms; 5. an area shelled with mustard gas is contaminated for days and in warm, dry weather its potency is felt for weeks; 6. except for a slight mustard or garlic odor, there is no immediate realization of the presence of mustard gas for the delay action on the exposed subject consumes from two to six hours; (hence, greater doses can unwittingly be administered, with more serious effect); 7. in concentrations as slight as one part in 4,000,000, conjunctivitis of the eye results, while one part in 3,000,000 will cause skin burns (these take from three weeks to three months to heal); 8. as the specific gravity of mustard gas is much heavier than air, it sinks into all depressions, dugouts, houses, permeates all objects with which it comes in contact, and remains there for weeks; 9. its vapor can be transferred from one contaminated person to another (doctors and nurses during the war were infected, as they treated and cared for the gassed soldiers, by the vapor of mustard gas arising from the clothing of their patients, suffering severe external burns and in some deeply-inhaled cases severe burns in the respiratory tract); 10. this gas has a similar effect on all animals, as well as on all vegetation. Animals rarely blister, though the horse seems to be most sensitive to mustard gas. Vegetation, which has been destroyed by gas bombardments, comes up afresh the following year. Chloride of lime sprinkled over the infected areas, neutralizes the action of mustard gas and makes the ground passable. Such was the demand for it during the war, that the supply was inadequate.

Indeed, the military virtues of mustard gas—called by the French yperite because first liberated at Ypres and by the Germans, yellow cross from the shell marking, bearing that insignia—are not yet exhausted. Sufficient qualities have been enumerated to appreciate those unnamed. Its tactical use, based on its vesicant or burning action, as well as its action as a powerful pulmonary irritant, are:

to effectively neutralize intervening territory, to get enemy casualties, to destroy morale, to besiege the enemy before an attack, to drench rear communications and thus break continuity; to annihilate rest areas in the rear as well as concentration camps, to plant drums of mustard gas in the territory which the enemy must traverse, whose explosion as they passed would result in great numbers of casualties, etc. Incased in a high explosive shell, its lethal action on enemy artillerymen is guaranteed. Simply sprinkling it from an airplane will affect all beneath. Surprise airplane attacks with mustard gas, at night, when gas masks are removed, are recommended for decisive results.

The gas mask, if constantly worn—day after day and night after night—will protect the respiratory tract but, unless one wears stiff, oiled clothing, special shoes and oiled gloves (because of the obvious detractions to this garb, it was not universally issued) one is liable to get mustard gas burns. Some salves with a vaseline basis are of temporary protection and help. Pathological symptoms of mustard gassing start, after two or three hours exposure, with smarting and watering of the eyes, running discharge from the nose, sneezing as in an acute cold, nausea, vomiting, and epigastric pain. This is a so-called light case of gassing from which all recover. Then, slowly, if longer exposed, other symptoms develop, the eyes become closed with pus, the voice gradually becomes harsh, laryngitis with a hard, dry cough appears. The skin, at the same time is covered with a red blush which marks the first stage in the vesicant action. This, in twenty-four hours, becomes blistered with large pus blebs. Thus lies our patient who had been exposed to a slightly stronger or longer concentration of mustard gas, a casualty for at least four weeks, suffering from painful skin burns, which very often become serious, because of the difficulty of preventing infection. The vapor of mustard gas causes burns and casualties as much as the liquid mustard gas itself, only more slowly. For example, a drop of the liquid is placed on a piece of paper. This is then placed on top of a man's coat sleeve and left for five minutes. The vapor, not the liquid, penetrates his coat and woolen shirt and causes blistering of the arm which takes six weeks to heal. Thus, mustard gas vapor as it arises with the sun from the impregnated earth is dangerous to all who tread there, for weeks. It sinks into depressions and houses and is only eradicated by the cleansing action of time and chloride of lime.

If airplanes can and will sprinkle whole areas (cities and towns) with, one hopes, a slight concentration of mustard gas, whole populations will be reduced to the condition of real suffering, if not suffocation in subways, homes will be tenantless, and factories and all the appurtenances of civilization will be useless.

If, however, a strong concentration is used, the same symptoms first appear, to be followed by the more serious bronchial irritation which may develop into acute septic broncho-pneumonia when death occurs. Given a serene, warm, cloudless night and no perfectly-fitting gas masks freshly made and in perfect repair, and whole populations will be at the mercy of a surprise attack with the above results. Mix in the airplane bombs, carrying mustard gas some chlorobenzene or carbon tetrachloride and the lethal results are doubly sure. Civilization within the cruising radius of the airplane and dirigible is at the mercy of such eventualities. The pathology of these lethal cases is well represented by case No. 6, quoted from report No. 17, British Medical Committee, entitled "Report on Cases of Poisoning by Mustard Gas with Special Reference to Histological Changes and to Alteration in the Leucocyte Count." The case well describes the congestion and pathological changes occurring after a lethal dose of mustard gas:

Case 6

Gnr. B., aet. 45, was gassed on 12th Oct. On admission to the Field Ambulance some hours later there was cough, retching and vomiting, the eyes were painful and smarting, and the throat was dry. When admitted to the Casualty Clearing Station 24 hours later there were blisters on the right arm and chin, with redness of the forearms. The eyelids were oedematous and there was conjunctivitis. The throat and chest were painful, but there was no cough. A few rales were heard on auscultation. The pulse was 80 and the heart appeared normal. On admission to No. - - General Hospital on 14th October, 48 hours after gassing, there were obvious burns, with blistering of the face and chest. There was severe conjunctivitis with much photophobia and lachrymation, and laryngitis and bronchitis were present. The patient, a stoutish, elderly man, was very feeble and rather blue. On 15th October, when the first blood examination was made, the patient was very ill, with cyanosis, bronchitis and aphonia, and there was copious purulent expectoration and distressing dyspnoea. A leucocyte count at 12.30 p. m. showed total leucocytes 14,500, neutrophil polymorphs

14,370 (99.1 per cent), eosinophils none, basophils none, lymphocytes 70 (0.5 per cent), large mononuclears 60 (0.4 per cent). Next day the patient was no better, and there were signs of pneumonic consolidated at both bases. A leucocyte count was made at 4 p. m. four days after gassing. Total leucocytes 14,300, neutrophil polymorphs 14,040 (98.2 per cent), lymphocytes 170 (1.2 per cent), large mononuclears 90 (0.6 per cent). Many of the neutrophils were abnormally large, with six or eight lobes to the nuclei. By 18th October the patient was slightly delirious. He no longer kept his eyes closed, so that cloudiness of the corneae was very obvious. The dullness at the bases of the lungs had extended well up the scapulae. Blood examination at 3 p. m. (six days after gassing) showed total leucocytes 2,800, neutrophils 2,670 (95.3 per cent), lymphocytes 90 (3.4 per cent), mononuclears 40 (1.3 per cent). The great majority of the neutrophils were of primitive type, with nuclei of one, two, and three lobes, but a few large polymorphs with nuclei of six and seven lobes were still seen. The patient died the same evening at 7.30, six days after gassing.

Post-mortem Examination (14 hours after death)

1. Respiratory Passages.—There is very intense membranous inflammation of the interior of the larynx, the epiglottis, and the uppermost inch of the trachea. The membrane is thick, yellow and adherent, and is covered on the surface with much mucopus, which can be washed off. The ventricle of the larynx is filled with similar purulent exudate, but without any underlying membrane. The mucosa over the arytenoid cartilages is very much thickened and oedematous and the seat of numerous punctiform haemorrhages. The rest of the trachea and the main bronchi show only a small amount of adherent membrane posteriorly. The mucosa in front, covering the cartilaginous rings, is intensely injected and the seat of innumerable tiny punctiform haemorrhages. The pharynx shows a somewhat patchily distributed membrane stopping short as usual at the commencement of the oesophagus. A few patches of membrane are also present on the uvula and soft palate. The posterior third of the tongue and the pillars of the fauces show considerable oedema.

2. Lungs and Pleurae.—There is well marked purulent bronchitis throughout both lungs, some of the tubes being filled with yellow, creamy pus, while others contain more viscid secretion. Early broncho-pneumonia is also present, but is confined to the basal portions of the lower lobes. Both lungs are greatly engorged and somewhat oedematous, the latter change most pronounced in the left upper lobe. There is an extensive old, caseous tuberculous lesion in the apical portion of the right upper lobe. The right pleural sac is completely

obliterated by old dense adhesions, in the midst of which are a number of old calcareous plaques. There is an early acute pleurisy over the greater part of the left lung, with a small amount of plastic exudation.

3. Other Organs.—The bronchial and tracheal glands are very much enlarged and intensely engorged, while they contain a notable excess of carbon. There are a few punctiform haemorrhages in the visceral pericardium on the posterior aspect of the heart. Tough, white, ante-mortem coagula of large size are present in all the chambers of the heart. The coronary arteries, especially the left, are the seat of well-marked patchy atheroma. In particular the descending branch of the left coronary has its calibre very seriously diminished. The cortical lipoid of the adrenals is much reduced, remaining only in patches. The brain and membranes show considerable general vascular engorgement, and there are a number of tiny punctiform haemorrhages into the ependyma of the lateral ventricles as well as into the white matter of the brain.

Before considering the means of protection against such probabilities in the development of chemical warfare on the modern scale, two intervening factors must be considered.

Other persistent gases, besides mustard gas, have been evolved since the World War closed. Dissimulating gases which prevent quick recognition of lethal gases have been and will be used again. There is the new lachrymator, bromobenzyl cyanide, persistent for at most a week, under favorable weather conditions, a superb agent for constant harrassing purposes. The prospect of weeping for a week, weeping so intensely that sight is prevented, cannot be a happy thought, for even the most lachrymose in our midst. Then, too, the mysterious Lewisite, heralded at the close of the war as a lethal gas, twice as dangerous as mustard gas, must be reckoned with. Lewisite, a mixture of acetylene gas and arsenic, is, in the pure state, a colorless oily liquid, with an odor so poetic waxes the military manual, like geraniums. Its chemical name is chlorvinyl-dichlorarsine, and the boiling point is 190° C., freezing point, 18° C. Assured by the chemical contents and the experience of those who know, Lewisite can be counted on in any future conflict to take an equal share with mustard gas, of casualties and deaths. There is equal assurance that the chemical laboratories in all the different producing countries are busy evolving new poison gases and new, unknown mixtures to startle the world in case of necessity. This chemical

activity amounts to competition. The chemists and scientists of the present and in the future will, of necessity, act as the guiding genius to the military leaders for, in their hands, rests the two all important elements for military success—the element of surprise and the element of the unknown chemical agent. The development of these elements into practical fighting arms is in the province of the military but the original suggestions and initiation must come from the scientists. A clear example of this closer interrelation may be seen in the development of the airplane. The scientists have developed a new metal, called "plass" or "aldur" which has properties such as invisibility in the air and tremendous strength (it is difficult to pierce with a bullet), two invaluable characteristics in the airplane of the future. Scientists have solved the question of airplane engine noise by installing new Maxim silencers. Radio control of airplanes has been developed to a degree of perfection, undreamed of a short time ago. Thus, the scientist has produced, through his researches, a silent, invisible, pilotless airplane. The military leader puts such knowledge to his own uses. Many further illustrations could be produced. These researches are proceeding in all countries and are as applicable and conducive to peace as to war. The balance in the scales rests, in the final analysis, with those who know what is in store for mankind if a world war should again be declared. Where it will end, and how it will end, is hard to see.

Second, the argument that chemical warfare is most humane, is based on the World War gas statistics. In examining these statistics, one point must be constantly emphasized. The inaccuracy of these figures is recognized by all who study the conflicting accounts. For instance, the total American casualties, cited by the British Captain B. H. Liddell Hart in his book, *The Remaking of Modern Armies*, is 262,365, of which 74,779 were gas casualties. General Fries, in his book, *Chemical Warfare*, quoting the same authoritative source as Captain Hart, namely, the Surgeon General of the United States, arrives at these figures, total American casualties, 258,338 of which 70,752 were due to poison gas. The discrepancy of four thousand and twenty-seven is sizable enough to affect percentages as well as four thousand homes. These differences represent no reflection on the Surgeon General's office or on the authors quoted. It is indicative, however, of the physical impossibility of collecting data when

the officer on the firing line, buoying up the courage of his men against shot, shell and poison gas, has to decide exactly which of the three first killed his men.

GAS CASUALTIES IN WORLD WAR

Country	Number	Deaths	Percentage of deaths to casualties
Russia[1]	475,340	56,000	11.7
France	190,000	8,000	4.2
Italy	13,000	4,627	34.7
United States	70,752	1,421	2.0
Great Britain	180,983	6,062	3.3
Germany	78,663	2,280	2.9

"It is practically impossible to obtain accurate data concerning the number of casualties and deaths attributable to gas in many of the battle engagements for the reason that the conditions accompanying severe fighting allowed little opportunity for differentiating those dying from the effects of gas and from those killed by rifle bullet, shell and weapons other than gas." (Gilchrist.) It seems astonishing that, on the basis of these unreliable figures, the main argument for the humanity of gas warfare is built up.

In discussing American gas casualties and deaths, we will quote from General A. A. Fries, head of the Chemical Warfare Service of the U. S. A. in France, as follows: "In the past war, more than 27 out of every 100 Americans killed and wounded suffered from gas alone. You may say that many of the wounds were light. That is true; but those men were put out of the battle line for from one to four months—divisions, corps and armies almost broken up—and yet the use of gas in that war was a child's game compared to what it will be in the future." (*Chemical Warfare*, p. 375.) Then later, General Fries explains clearly the reason for the low figure in gas casualties, a reason which the pro-poison gas advocates never mention. "Unquestionably many of those who died on the battlefield from other causes suffered also from gas. No other single element of war, unless you call powder a basic element, accounted for so many casualties among the American troops. Indeed, it is believed

[1] Unreliable.

that a greater number of casualties was not inflicted by any other arm of the Service, unless possibly the infantry, and even in that case it would be necessary to account for all injured by bullets, the bayonet, machine guns, and hand grenades. This is true, in spite of the fact that the German was so nearly completely out of gas when the Americans began their offensive at St. Mihiel and the Argonne, that practically no gas casualties occurred during the St. Mihiel offensive, and only a very few until after a week of the Argonne fighting. Judging from the results achieved at other times by an extensive use of mustard gas, it is believed that had the German possessed this gas and used it as he had used it a few other times, American casualties in the Argonne would have been doubled. In fact, the advance might even have been entirely stopped, thus prolonging the war into the year 1919." (*Chemical Warfare*, pp. 386–387.)

In the light of these facts, so fearlessly set forth by the head of our gas service in France, it seems a bit unwise to herald poison gas as "the least inhuman of all methods of warfare." Thereto, add the fact that, as we have above shown, airplanes sprinkling gas will cover wide areas and deluge large cities with the most lethal, secret poison gases, and the advocacy for the continuance of chemical warfare may prove a boomerang. In other words, moral opposition to chemical warfare is based on the military facts in the case and not on "mere sentimentality" as one writer would have us believe. Fired over into enemy territory by long range guns and dropped from on high by airplane bombs, poison gas will reach and affect millions of non-combatants. With the first stage of chemical warfare already past (during the World War), we can confidently expect the interim development to yield results for the next war, beyond all human expectations. A mere phantom gesture of possible future aerial war development was presaged last summer, when after staging an aerial offense and defense over London for the purpose of determining its vulnerability to air raids with poison gas, a great military authority reported in the London *Times*: "No local defenses can possibly prevent an air raid over London, and the same is true of every large town in the country. The real defense against air raids is our power to do worse to the enemy's capital before he can do it to ours."

The British statistics for the war are: total casualties from bullet, shell, and bayonet 2,797,693, of whom 879,000 died—a proportion of nearly one dead to three wounded. Total gas casualties, 180,983

of whom 6,062 died, or one in thirty. (As quoted from Hart *Remaking of Modern Armies*, p. 82.) Thus Captain Hart generalizes from these figures, ignoring in his zeal the tremendously serious development of lethal gases since the war. "What is the clear deduction from these statistics? That 'poison gas' is from ten to twelve times as humane a weapon as bullets or high explosive. This would be so, even with acutely painful forms of gas. For what man would not prefer an interval of suffering so long as life and not death lay at the end?"

But suppose that your beloved London is drenched in a surprise night attack with some mustard gas and Lewisite, good Captain? Is there any choice for the seven or eight odd millions huddled in that great metropolis, between life or death? Perhaps, in such an unhoped for occurrence, life is less preferable. The more the intelligent lay mind, unbiased by the technical military and detailed chemical equations investigates the past, present, and probable future of chemical warfare, the more firmly does the conviction grow that civilization stands at the crossroads—the High Road leads to peace and safety and the improvement of the human race; the Low Road leads to war, poison gas, and indiscriminate reversion to worse than barbarism.

Are there any mitigating circumstances which might so affect this conclusion that civilization will find a middle road? Could mechanical protection against chemical warfare as well as diplomatic protection be classed as mitigating circumstances? If so, how far have these means of protection actually gone since the World War and how reliable are they in case of need?

Possible Protection—Gas Masks

Mechanical protection against chemical warfare has developed with the development of poisonous gases and smokes. At first, when the chlorine cloud slowly but irresistibly swept across the battlefield at Ypres on April 22, 1915, there was no protection of any kind against the impending horror. Moistened cloths, damp earth, rags soaked in water or washing soda solution were used in the almost hopeless attempt to secure protection. The frenzy of those hours was indescribable. All within the strong concentration area perished. Those on the outskirts rushed back to spread the incredible news. Confirmation of the horror came in the thousands dead, in the long

line of temporarily blinded, in the terrifying reports which those who survived gave to the waiting world. Had the Germans realized the success of their first gas attack, the war would have ended differently. They did not know that the road was clear to the Channel ports.

Great Britain against whose soldiers this first attack was directed was aroused to the need for protection against this new form of warfare and soon, through the instantaneous response of her women, sent over crude cotton waste respirators, soaked in a soda solution. Then followed more adequate masks. The Black Veiling respirator consisted of cotton waste, soaked in sodium thiosulphate, washing soda, glycerine and water and wrapped in the veiling to protect eyes as well as the nose. Leakage was inevitable in such a crude mask and so the Hypo helmet was evolved. It consisted solely of a flannel bag, dipped in the same solution as the respirator, but it could be pulled over the head and a mica insert allowed for vision. Against chlorine, it was a fairly successful protection. But other gases were going to be used. Against phosgene, flannelette soaked in a solution of sodium phenolate (carbolic acid) and glycerine was quickly made and called the P helmet. It had an expiratory valve to help the breathing of the wearer. Hexamethylenetetramine was added to protect against strong concentrations. This was, then, called the PH helmet. Goggles were adjusted to the face with rubber sponge attachments for protection against lachrymators. But, when it was found that soldiers would use the goggles for a poison gas attack, in complete ignorance of the fatal difference between a lachrymator and a lethal-gas, the goggles were withdrawn. Still the gas mask was inadequate. The PH helmet was hot and stuffy in summer (when most attacks occurred), it deteriorated upon exposure to air, when wet it burned the foreheads of the men, it had an unpleasant odor, and it offered no protection to lachrymator gases which quickly penetrated the flannelette helmet and so irritated the watery eyes that the helmet was torn off and the soldier was exposed to a lethal gas. The English then developed the mask with canister attachment in 1916 to meet the lethal, persistent gas period. Briefly, the face-piece, made of rubberized material and attached to the head with tape and elastic bands, was also attached by a long tube to a canister, carried on the back. In the canister, there was placed 40% wood charcoal and 60% soda-lime granules. A paper filter and a heavy

wire screen in the canister eliminated the danger of particulate gases reaching the wearer. A valve at the bottom of the canister allows for the intaking breaths. Then, the inspired air travels through the canister, and is purified as it goes through, reaching the wearer by the tube. An expiratory valve allows for the expulsion of the used air. A nose clip and a special mouthpiece force breathing through the mouth. Heat radiation from the face causes moisture to form on the eyepieces and despite anti-dimming paste, makes vision very uncertain, if not impossible. This British gas mask protects against the known poison gases and lachrymators. It is useless against any unknown combination of gases or new gas. The same holds true for all gas masks.

The French, too, developed their own gas mask. Without entering too deeply into the details of the evolution of the gas mask, it can here be recorded that the M–2 mask, the first French protection against poison gas, was made of layers of muslin impregnated with a chemical solution, somewhat similar to the English P and PH helmet, though the mask itself fitted more tightly. Then, the French Tissot mask was evolved, admittedly more comfortable than the British canister with face piece, though less durable. Finally, a mask similar in construction to the German mask, was developed. It was called the A.R.S. mask (Appareil Respiratoire Special). In the drum which is screwed into the face-piece direct, are three layers of chemicals, the lower layer consists of soda-lime, mixed with charcoal and zinc oxide, moistened with glycerine, the next layer is charcoal, finely ground, the top layer is a thin layer of absorbent cotton. The wearer breathes through this drum by means of the perforated bottom—purifying the air as it is drawn up.

The German mask consists of a leather face-piece, with specially prepared anti-dimming eyepieces, and a drum to be screwed into the face-piece. Separate drums were always carried, slung across the back in case the mask protection has been diminished. In the drum or canister, there were alternating layers of thin screening with absorbent chemicals. The face-piece and mask were firmly attached to the head by strongly woven bands. There were no valves in the German mask as both inhaled and exhaled air passed through the canister.

The American mask profited by the experience of the Allies. Our Chemical Warfare Service consulting with the Allies' experience

evolved a mask protection for our soldiers which held against some of the strongest poison gas attacks. As the war continued, the gas attacks with mustard gas increased, necessitating the wearing of the mask over long periods of time. Eight hours was not uncommon at a stretch. Hence, the gas mask must be as comfortable as possible. The American mask, the 1919 model, consists of a face-piece of rubberized stockinet, with special eyepieces set in. Thereto is attached a long rubber tube which leads to the canister, carried on the back. In the canister are to be found a mixture of soda-lime and charcoal. These absorbents, and the fine wire mesh screening were found adequate to meet the poison gas development as the World War witnessed it. They were selected because of their absorptive activity, absorptive capacity, versatility, mechanical strength, chemical stability, low breathing resistance, ease of manufacture, and availability of materials.

The dependability of the gas mask during a poison gas attack is proportionate to the reaction of the individual wearer. Given well-trained troops, carefully versed in the gas attack procedure and gas masks in perfect condition, then, there is good protection against non-persistent gases, whether lethal or sensory irritant, from the present gas mask. But, if the troops have become panicky under constant gas attacks, and the masks, through constant usage are exhausted or torn, then, there is no help in the gas mask. No one knows the exact life of a gas mask—that is, no one knows how long the chemicals in the canister are effectively active. Some military experts say that the American gas mask is good for fifty hours continuous use, others disagree with this estimate, making the total much less. The following table from Fries and West, *Chemical Warfare*, p. 218, gives some idea of the time it takes to detect the gas odor. The figures represent time in minutes under laboratory conditions till the first traces of gas begin to come through the mask:

Name of gas	p.p.m.	U. S. Type H	British S.B.R.	French A.R.S.	German
chloropicrin	1000	770	17	2	43
phosgene	2500	85	54	5	16
hydrocyanic acid	500	70	90	..	10
mustard gas	100	1800	..	35	195

The reissue and the constant repair of gas masks developed into an important department of the Chemical Warfare Service. The sterilization of the masks was another problem which needed constant attention. The possibility of leakage through the carelessness of the many operators necessary to complete a mask, was and always will be a source of danger. A small rip or a few stitches slipped, will permit the gas to enter direct to the user and cause a casualty. As mentioned above, the present mask is designed to meet the present known gases. It is useless in the face of a new gas. As General Fries says: "Thus the development of masks must be kept parallel with the development of gases and methods of discharging them. Otherwise, a new gas invented may penetrate existing masks and preparations be carried far towards using it before the development of masks is undertaken to care for the new gas." The race between new gases and old masks, in peace time, must be kept very secret so that when the conflict is on, the aggressor nation lets loose a flood of new poison gas over the nation defending itself against an unknown chemical agent. Defenseless in the face of this sudden attack, masks are useless (for it takes time to analyze the new gas and then to reconstruct the gas mask) and the nation attacked must lie supine and watch itself being annihilated. This is no exaggeration, it is the actual truth of the present and future situation in regard to chemical warfare, unemotionally stated.

There is one phase of the gas mask which needs further elucidation. The physiological effect of the long-continued use of the mask has been studied, because the introduction of mustard gas, which is persistent for days and even weeks, demanded expert knowledge on the reaction of the mask on the wearer. If the gas mask must be continuously worn for long periods at a stretch, it was found that the efficiency of the soldier was reduced at least twenty-five per cent. Quoting from Fries: "Physical vigor is one of the greatest assets in any army. Gas, used properly and in quantities that will be easily attainable in future wars, will make the wearing of masks a continuous affair for all troops within two to five miles of the front line, or in certain places for many miles beyond. If it never killed a man, the reduction in physical vigor and, therefor, in efficiency of an army forced at all times to wear masks, would amount to at least twenty-five per cent, equivalent to disabling a quarter of a million men out of an army of a million." This can be easily understood

when the difficulty of breathing under the stress of hard manual labor is recalled, even with the best of normal conditions present. But, when the same arduous labor must be performed with a gas mask on, the difficulty of continued labor and artificial breathing makes the resulting product one-quarter less efficient. Ask an artillery man how he enjoyed placing a gun in position after a long haul with a gas mask on. The resistance to breathing which even the best gas mask occasions, has physiological effects that are serious when extended over long periods. Then, too, the necessity of sleeping with the mask on, due to surprise attacks at night, was realized, as the intensity of gas warfare increased and lethal gases were freely used. The difficulty of trying to sleep, breathing through a gas mask can only be appreciated after one has tried it. Indeed, the mental and physical effect of the gas mask on the wearer is proportionately unfavorable with the length of time it must be kept on. In summer, it is almost unbearable. Some of the soldiers would, in desperation, finally rip off the mask and they would say that death was preferable to such living torture. This is comprehensible in the light of the following: "The importance of resistance to breathing lies in: (1) the effect on the circulation of the blood, and (2) the changes in the lung tissue, which seriously interfere with the gas exchange between the outside air and the blood. Data have been presented to draw attention to the seriousness of resistance to inspiration. In these reports, it was suggested that the deleterious effects on the body consist in changes in the blood pressure, increased work of the right side of the heart, and an increase in the blood and lymph content of the lungs. Resistance also decreases the minute-volume of air breathed and thereby increases the percentage of carbon dioxide in the expired air. The foregoing changes are all deleterious.

"Although the chief problem of resistance in gas mask design concerns inspiration, nevertheless resistance to expiration is an important factor. The expired air of the lungs contains carbon dioxide for which means of escape must be provided. The expiratory act is more passive than the inspiratory act, and resistance to expiration is, therefore, more keenly felt than resistance to inspiration. It is then imperative that the exhale valve be so arranged as to allow for the escape of the entire amount of air during the time of expiration with the least possible resistance. The data of the

laboratory indicates that seldom, if ever, do expiratory rates rise above a velocity of 150 to 175 per minute. The effect of resistance to exhalation upon the vital organs of the body is not dissimilar to that of inspiration."

Surveying the protection which the combatant and non-combatant expect to receive from the gas mask in the chemical warfare of the future, several facts bear recapitulation. The present gas mask is designed to meet the present known gases. It is useless when a new gas is liberated. New poison gases are being discovered and held as State secrets. The present gas mask is thoroughly uncomfortable and requires careful training before the user can receive proper benefit. When worn for a long period of time (over eight hours) the gas mask affects adversely the wearer, mentally and physically. Persistent lethal and irritant gases remain a menace for days and weeks. Gas masks must be kept in perfect repair and must fit the individual head closely. Gas masks are ineffective after a concentrated lethal gas attack (the chemicals need renewing). Constant issue and reissue of gas masks is imperative if they are to act as real protection. Under these conditions, it is physically impossible to distribute gas masks to the non-combatant. The non-combatant stay-at-home is doomed. In the light of these facts, only the trained combatant need expect any safety against poison gas if there ever should be another conflict. A noted chemist was heard to say: "My only advice to the non-combatant in the next war is, either run for the front line trenches or climb to the top of a skyscraper and stay there until the war is over." Disregarding this advice, the question can now be put fairly and squarely—Is there no hope for civilization?

The diplomatic field must be first explored before that question can be answered.

Possible Protection—International Agreements

(Since the World War)

When the time came to write the Peace Treaties in 1919, the memory of chemical warfare, even as comparatively mild as it was, had burned rather deeply into the souls of the puissant statesmen, assembled in Paris. Therefor, in the Treaty of Versailles with Germany, Article 171 definitely states: "The use of asphyxiating,

poisonous or other gases and all analogous liquids, materials or devices being prohibited, their manufacture and importation are strictly forbidden in Germany. The same applies to materials specially intended for the manufacture, storage and use of the said products or devices. The manufacture and the importation into Germany of armoured cars, tanks and all similar constructions suitable for use in war are also prohibited."

At the same time, in The Treaty of Trianon, between the Allied and Associated Powers and Hungary, Article 119 expressly states: "The use of flame throwers, asphyxiating, poisonous or other gases, and all similar liquids, materials or devices being prohibited, their manufacture and importation are strictly forbidden in Hungary. Material specially intended for the manufacture, storage or use of the said products or devices is equally forbidden. The manufacture and importation into Hungary of armoured cars, tanks or any similar machines suitable for use in war are equally forbidden."

In the treaty of St. Germain, between the Allied and Associated Powers and Austria, Article 135 clearly states: "The use of flame throwers, asphyxiating, poisonous or other gases, and all similar liquids, materials or devices being prohibited, their manufacture and importation are strictly forbidden in Austria. Material specially intended for the manufacture, storage or use of the said products or devices is equally forbidden. The manufacture and importation into Austria of armoured cars, tanks or any similar machines suitable for use in war are equally forbidden."

Identic wording with the above is found in Article 82 of the Treaty of Neuilly between the Allied and Associated Powers and Bulgaria, and in Article 176 of the Treaty of Sèvres, there is identically similar wording, restricting Turkey. Thus, five major nations in the center of Europe—Germany, Austria, Hungary, Bulgaria, and Turkey are chemically disarmed by edict of the peace treaties. This is an important point which some advocates for chemical warfare are prone to ignore or conveniently forget.

The victor nations in the World War, then, tackled the problem of chemical disarmament for themselves in the 1921–1922 Treaty of Washington. This Naval Disarmament conference, consisting of delegates from Great Britain, France, Italy, Japan, United States, appended Article V, restricting and forbidding the use of poison gas. Article V reads: "The resolution was adopted unanimously

by the committee and was later incorporated as Article V of the treaty signed by the five powers on February 6, 1922, in the following form:

'The use in war of asphyxiating, poisonous or other gases, and all analogous liquids, materials or devices having been justly condemned by the general opinion of the civilized world and a prohibition of such use having been declared in treaties to which a majority of the civilized powers are parties.

'The signatory powers, to the end that this prohibition shall be universally accepted as a part of international law binding alike the conscience and practice of nations, declare their assent to such prohibition, agree to be bound thereby as between themselves and invite all other civilized nations to adhere thereto.' "

In connection with the work of the Naval Disarmament Conference's committees, it is interesting to note here the reactions of the investigating committee's report on the subject of chemical warfare. General Pershing's committee submits the following in his report to Secretary Hughes:

"Chemical warfare should be abolished among the nations as abhorrent to civilization. It is a cruel, unfair and improper use of science. It is fraught with the gravest dangers to non-combatants and demoralizes the better instincts of humanity."

At the same time, the Navy reported, "The General Board of the Navy believes it to be sound policy to prohibit gas warfare in every form and against every objective and so recommends." On the basis of these recommendations coming from such unimpeachable authority, the prohibition of gas warfare convention was included in the general treaty and the weight of this authority counted favorably with the Senate of the United States, which ratified this convention.

Great Britain, Japan, Italy, and the United States ratified Article V of the Washington treaty abolishing poison gas. France did not ratify this article as the Secretary of the League of Nations in the office of the Minister for Foreign Affairs in Paris definitely states in the following words: "The League of Nations Service begs to inform the Library of the League of Nations Association (New York) that the French Government have not ratified the Washington treaty about the use of noxious gases in warfare. They have signed and ratified the Geneva protocol for the same purpose." Hence, the

poison gas convention in the Washington treaty is not binding on the signatories and the development of chemical warfare goes on, unchecked.

It is interesting, in the light of the World War history to note, in passing, an attempt to prohibit the use of poison gas, while the war was in progress. A cable from Colonel House, dated London, May 19th, 1915, 4 p. m. (the first poison gas liberated on the Western front April 22, 1915) reads as follows: "Rush for the President: Please transmit following to Berlin Embassy immediately: Have concluded to cable my suggestion rather than delay it by letter. Can you not induce the German Government to answer our note by proposing that if England will permit foodstuffs in the near future to go to neutral ports without question, Germany will discontinue her submarine warfare on merchant vessels and will also discontinue the use of poison gas? Such a proposal from Germany at this time will give her great advantage, and, in my opinion, she will make a grave mistake if she does not seize it." Edward House. But, this ended in failure, due in part to the insistence of Germany on continuing its submarine warfare, to the desire of Great Britain to obtain an abandonment of the use of poison gases by Germany as a condition of relaxing the food blockade, etc.

But, after the war, renewed efforts were made to ban chemical warfare, by varying nations and groups of nations. As we have seen in the case of the Naval Disarmament Conference, the attempts are highly interesting and significant.

Then, a Commission of Jurists, including their Military and Naval Advisors, representing France, Great Britain, Italy, Japan, Holland, and the United States met in conference at the Hague from December 11, 1922 to February 19, 1923 "for the purpose of formulating a code of rules for the regulation of the use of aircraft and of radio in time of war."

The rules which govern aerial bombardment, in the Rules of Air Warfare, are as follows:

> Article 22: Aerial bombardment for the purpose of terrorizing the civilian population, of destroying or damaging private property not of military character, or of injuring non-combatants is prohibited.
>
> Article 23: Aerial bombardment for the purpose of enforcing compliance with requisitions in kind or payment of contributions in money is prohibited.

Article 24: (1) Aerial bombardment is legitimate only when directed at a military objective, that is to say, an object of which the destruction or injury would constitute a distinct military advantage to the belligerent.

(2) Such bombardment is legitimate only when directed exclusively at the following objectives: military forces; military works, military establishments or depots; factories constituting important and well known centers engaged in the manufacture of arms, ammunition or distinctively military supplies; lines of communication or transportation used for military purposes.

(3) The bombardment of cities, towns, villages, dwellings or buildings not in the immediate neighborhood of the operations of land forces is prohibited. In cases where the objectives specified in paragraph 2 are so situated that they cannot be bombarded without the indiscriminate bombardment of the civilian population, the aircraft must abstain from bombardment.

(4) In the immediate neighborhood of the operations of land forces the bombardment of cities, towns, villages, dwellings or buildings is legitimate provided that there exists a reasonable presumption that the military concentration is sufficiently important to justify such bombardment, having regard to the danger thus caused to the civilian population.

(5) A belligerent State is liable to pay compensation for injuries to person or to property caused by the violation by any of its officers or forces of the provisions of this article.

This was one way of attempting to limit chemical warfare. But no nation represented at that conference has even ratified the action of its delegates. Hence, these rules have no binding force.

The League of Nations, seeking to find a way through the disarmament maze, has year after year brought up the vexing question of chemical disarmament as part of the general problem for the total reduction of armaments. Because of the complexity and wide ramifications of the general problem of reduction in armaments and in particular, the difficulties in the path of chemical disarmament, chemical disarmament has not progressed under League auspices up to the present. It is only by the united cooperation of League and non-League members, however, that this problem of chemical disarmament can and will be solved. However, by resolution of the Council, May 9, 1920, a commission was authorized to carefully look into the question of chemical warfare. This first commission,

the members of which were appointed by and were representatives of their governments, consisted of the following personnel:

Belgium: Lieut. Gen. de Ceunick, Col. van Crombrugge.
Brazil: Col. Andrade Neves, Rear Admiral de Souza e Silva.
British Empire: Col. J. S. Lowe, D.S.O.; Rear Admiral Aubrey C. H. Smith, C.B.; M.V.O. Commander N. W. Diggle, C.M.G.; Paymaster Commander E. Kennedy, British Air Representative.
France: Marshall Fayolle, Col. Requin, Vice Admiral Jehenne, Capt. Deleuze, Gen. Dumesnil, Col. Faure.
Italy: Brig. Gen. de Marinis Stendardo di Ricigliano, Vice Admiral Baron Acton, Capt. Don F. Ruspoli.
Japan: Brig. Gen. Hayashi, Lieut. Col. K. Shinomoto, Rear Admiral Kiyokawa, Capt. Takenaka, Capt. Yasutomi, Capt. Kuni Usui, Capt. Ogura, Cao. Giga.
Spain: Brig. Gen. Don Juan Garcia Benitez, Lieut. Col. Carlos Espinosa de Los Monteros, Rear Admiral Marquis de Magaz, Capt. J. Montogut, Lt. Col. Garcia de Pruneda.
Sweden: Col. O. E. Nygren, Maj. S. H. Gadd, Capt. C. F. W. de Riben, Capt. E. W. H. de Wrange.
Czechoslovakia: Gen. Vladimir Klecanda, Commandant d'Etat-Major Rudolf Kunzl Jizersky, Col. Sylvester Blaha.
Uruguay: Major Pedro Sicco.

This distinguished commission and succeeding ones have reported to the Assembly of the League in session each September. The response of the Assembly has been couched in these or similar terms:

The Assembly, having examined the report of the Temporary Mixed Commission with regard to the probable effects on warfare of chemical discoveries;

Being convinced that the means which modern science places at the service of warfare renders the latter a great danger to civilization;

Recalling the seventh resolution of the Third Assembly regarding the adhesion of all States to the Treaty concluded at Washington on February 6, 1922, concerning the use of asphyxiating gases in time of war:

Requests the Council, if it considers it desirable, to publish the report of the Temporary Mixed Commission and if advisable, to encourage the work of making information on this subject generally accessible to the public;

Noting, on the other hand, the facility and rapidity with which factories for producing chemical substances required in

peace time can be transformed into factories for chemical warfare:

Recommends that the attention of public opinion throughout the world be drawn to the necessity of endeavoring, in the first place, to remove the causes of war by the pacific settlement of disputes and by the solution of the problem of security, in order that nations may be no longer tempted to utilize their economic, industrial or scientific power as weapons of war.

As the report of the special committee appointed by the Temporary Mixed Commission for the Reduction of Armaments from its own personnel in 1924 is of such outstanding interest, it will be quoted in full. This report, based on the answers to questionnaires sent to the leading chemists and experts in the world, was signed by the following who were appointed the investigating committee: Viscount Cecil, Admiral Segrave (replaced by Admiral Aubrey Smith), General de Marinis, Colonel Requin. The scope of the questionnaire, as submitted to each expert, was defined thus:

The aim is to show to the public opinion of the world the effects which would be produced by the most powerful means of destruction placed at the service of modern warfare and by modern science.

It will be borne in mind that henceforward an armed nation, utilizing the whole of its human and material resources, will attempt to strike, not only at the combatants on the enemy's front, but at the whole enemy nation in arms—its population, its riches and its resources of every kind.

War of this sort, which carries destruction beyond the fighting lines and which renders opposing nations vulnerable to the extreme limits of their territories, has been made possible by the increasing range of modern guns, by the far-reaching activity of air forces and by conveying and disseminating in other ways the means of destruction.

Without discussing the legitimacy of such practices, we may endeavor to discover what is possible in warfare, whether permitted or not by the laws of war, in order that the public may have an accurate conception of the dangers which it has to fear.

In these circumstances, it is desirable to obtain from the most qualified experts as detailed and complete a statement as possible of the effect which would be produced—

on animal life,

on vegetable life,

on the wealth and resources of all kinds of a country which is attacked at any point of its territory;

(1) By chemical warfare by means of the most powerful explosives, chemical products and gases, as already practised and as further developed since the last war;

(2) By bacteriological warfare by means of microbes or any other agent if, in defiance of all human laws, its effectiveness should induce nations to adopt it.

The following experts answered the questionnaire: Prof. André Mayer, of the College de France; Prof. Angelo Angeli, of the Royal Institution of Higher Studies at Florence; Prof. Pfeiffer of Breslau; Prof. J. Bordet, of the Pasteur Institute, Brussels; Prof. W. B. Cannon, of the Harvard School of Medicine; Prof. Th. Madsen, of Copenhagen; Senator Paterno, of Rome University; and Prof. J. E. Zanetti, of Columbia University.

This is their report.

1. Chemical Warfare

It is well known that, after the first violation of the Hague Convention, chemical warfare was employed with effect by the belligerents during the last war as extensively as any other arm. It is to be feared that it will be still more so in the future. It should be noted that this form of warfare proved to be effective in circumstances in which other arms would have produced little or no effect.

Prof. Angeli writes:

"Though the experience of the recent war has shown that no fortifications or armour can resist the force of modern explosives, the men themselves could at least find safe shelter from them in trenches, caves or dugouts sunk deep underground. But poisonous gases can go everywhere, both in the open and into the dugouts."

The various methods employed, the wave or cloud of heavy gas borne by the wind towards the enemy, the firing of poison shells intended to produce clouds of very thick gas in the enemy lines, or to poison the ground, were directed against, and reached combatants in the front lines. But it is possible to conceive of other methods in the future, such as the dropping from aircraft of bombs or other containers filled with noxious products, which would strike at civilian populations as surely as at combatants. "It is doubtful," writes Prof. André Mayer, "whether the peoples of the world are aware of the power of this weapon and the danger which threatens them." Prof. W. B. Cannon goes still further when he states that "we have seen in the great war nothing approaching the probabilities of destruction of manufacturing centres and civil populations that would be likely in case another great conflict should occur."

The term "gas" as used in connection with warfare does not correspond to the scientific definition of gases. In reality it includes not only gases but solids or liquid substances which are reduced to powder or spray in the air. These substances produce lesions in the human body, due to chemical changes quite distinct from the mechanical effects produced by explosives.

Such substances are not by any means rare. The majority are common materials ordinarily manufactured and employed in large quantities for peace-time requirements, so that "there is very little difference between the manufacture of pharmaceutical products and that of injurious substances used in war."

First of all, it will be noted that, as was emphasized by the Government experts at the Washington Conference, "many high explosives produce toxic gases that frequently cause death, as do those termed chemical-warfare gases."

Apart from this, arms intended to kill or disable an adversary have hitherto attained their object by more or less mechanical means. Their projectiles lacerated the human body and reached vital organs; and the wounds themselves caused asphyxiation to a greater or lesser degree as a result of haemorrhage. Chemical warfare utilizes a greater variety of methods for temporarily or permanently putting a man out of action. The chemicals act on the constituent elements of the tissues and cause changes which finally disturb the normal functions of the body and result in death. We may demonstrate the variety of its effects by taking two extreme cases; for instance, the action of carbon oxychloride, which produces suffocation, pulmonary complications and death, and that of benzyl bromide, the vapours of which, spreading over the ground, cause tears to run and prevent the adversary from opening his eyes, without, however, producing any serious after effects.

In the first case, the elimination of the adversary is carried to the point of death. In the second case, a temporary suspension of activity is obtained by a mild physiological effect. Between these two extremes there is a wide range of intermediate effects. We can, however, from the point of view of their physiological action alone, divide these noxious substances into three main categories:

Irritant (lachrymatory, sneeze-producing and blistering) agents;
Suffocating or asphyxiating agents;
Toxic agents.

Effects of Irritant Agents.

These bodies possess the property of putting a man out of action without killing him.

(a) LACHRYMATORY AGENTS deprive a man of one of his essential senses—sight. They produce intolerable pain in the neighborhood

of the external organs of sight and render a man practically blind as long as he remains in the gas impregnated atmosphere. But, "contrary to public popular opinion," says Professor Zanetti, "the blinding effects of these gases is purely temporary, being caused only by irritation of the membrane of the eyelids and not by any deep-seated effect on the eyeball or optic nerve. The effect usually passes in a few hours, or a few days at the most, and although the victim is as completely put out of action as if his eyes were gouged out, there is no record of permanently serious effect being produced thereby."

The efficacy of lachrymatory gas, coupled with its property of not causing permanent disablement, has led to its adoption by police organizations. By its means criminals may be captured without loss of life.

(b) Sneeze-Producing Agents are arsenical compounds very similar to the cacodylates used in therapeutics; they cause constant and uncontrollable sneezing, attacks of suffocation and intolerable headaches. They drive the men to get rid of their protecting masks, thus exposing them to the action of other toxic products which may be fired concurrently or immediately after the sneeze-producing gas.

(c) Blistering Agents. Certain products such as dichlorethylsulphide, also called "mustard gas" or "yperite," cause lesions to the skin and mucous membranes which may be of a very serious character. Whenever the skin is exposed even to the vapour exhailed from the slow evaporation of the yperite, blisters appear within a period of two to eight hours; they may merely be small blisters produced by slight exposure or, on the contrary, an extremely serious general blistering of the whole body produced by prolonged exposure to the vapours or actual contact with the liquid. The action of this gas produces necrosis of the mucous membranes and leaves a raw surface extremely susceptible to infection. In short, although the action of blistering gases may be combatted, and even in certain cases nullified, this action is nevertheless capable of producing most serious effects on the health of the men who have been subject to it.

Moreover—and this is the principal effect—soil which is saturated with yperite contaminates by contact persons who pass over it or are posted on it. The yperite penetrates the fabric of clothing and turns it into an actual blistering plaster, the blistering properties of which may be communicated by mere contact. The ground and any articles which have been impregnated with the gas remain dangerous for a number of days.

Effects of Suffocating or Asphyxiating Agents.

So-called suffocating or asphyxiating bodies cause fatal damage to the lungs. Thus chlorine, bromoacetone, chloropicrin, carbonic oxychloride and acrolein, when inhaled, cause haemorrhage into the air cavities of the lungs. Pulmonary edema causes death in the same manner as drowning, death being attended by very painful spasms. Of all the gases in this category, carbon oxychloride, also known as phosgene, has been the one most effectively employed.

Other agents directly affect the blood, e.g., carbon monoxyde, which usually causes death by syncope, and, contrary to general belief, without

pain. This absence of pain, coupled with the unconsciousness of the existence of any lesion, aggravates the dangers, as it is difficult to make the victims realise their serious condition and keep them from making any exertion which would add to the burden of an already overworked heart.

Effects of Toxic Agents.

Finally, the toxic agents of the nervous system, such as derivatives of prussic acid, kill by instantaneously suppressing the functions of the nervous system. The gases of this kind, however, which are at present known, only produce this paralysing effect when somewhat highly concentrated.

Multiple of Combined Effects.

It should not be supposed, however, as Professor Mayer very rightly observes that each of the substances which have been used in warfare possesses only one of the properties enumerated above.

"Most of them combine several. All the lachrymatory and suffocating gases are fatal if taken in large quantities. If the blistering substances, instead of affecting the skin, penetrate into the lungs, they produce fatal lesions. Thus the effect to which we refer when we speak of a lachrymatory or blistering substance is only the predominant effect. The alteration in the strength used—an alteration which may be obtained by changing the charge of the projectile or the concentration of fire—completely transforms the injurious effects. Thus a weak concentration of dichlorethylsulphide produces a simple inflammation of the eyes and acts like a blister applied to the skin; a strong concentration causes lesions of the eyes which produce blindness, and lesions of the lungs which lead to a progressive obstruction of the air channels and to death by slow suffocation. It would, therefore, be a mistake to classify chemical compounds according to the gravity of the symptoms to which they give rise.

"Combined effects consisting of various destructive actions may be obtained either by releasing several substances together or from one substance having several properties. In this connection, attention should be drawn to certain combined effects which have long been known and which are produced by explosives and gases. Most modern explosives at the moment of explosion give off gases, many of which are highly toxic, e. g., carbon monoxide, which destroys the action of the blood and is a typical asphyxiant. Many cases of asphyxiation resulting from explosions in confined spaces were observed in mine warfare."

After Effects of War Gas.

Although this view is not accepted unanimously, it would appear that lesions caused by noxious agents leave traces which permanently affect the victims. In particular, injury to the lungs may predispose to certain infectious diseases.

Possible Effects of New Discoveries.

The gases mentioned above, the effects of which have been briefly described, are gases which are well known and—it cannot be too often repeated—are in common use in industry in peace time. But no guaranty can be given that new substances will not be discovered which affect other functions of the body. "It is conceivable," observes Professor Zanetti, "that gases may be invented that would impair the digestive functions or, as was actually tried, which would cause severe vomiting or interfere, as carbon monoxide does, with the normal functions of the hemoglobin of the blood in carrying oxygen from the lungs to the tissue." That, it is true, is only a hypothesis. Senator Paterno considers that this hypothesis "ought not to be excluded," but, nevertheless, points out that nothing warrants us to believe that new substances of greater military value than any yet known can be discovered and manufactured on a large scale. "To say that, at the beginning of the war, about thirty asphyxiating gases were known, whereas, today there are more than 1,000, is for him an entirely valueless argument, seeing that this rapid increase from thirty to 1,000 does not include any recently discovered substances, and that phosgene, chloride of cyanogen and yperite, which occupied the foremost place among the thirty, still occupy the same place among the 1,000. The obvious conclusion to be drawn from this fact is that the fresh researches carried out on the 1,000 substances have proved fruitless," and Professor Paterno, although he "believes that chemical preparations for warfare in general is indispensable," concludes, as regards the question of asphyxiating gases, "that we must neither hope nor fear that the progress of chemistry will lead to any greater success in the discovery of these gases than in discovering explosives."

Effects of Gas on Animals.

The effects on animals are essentially the same as those on human beings and the differences which have been observed in the sensitiveness of the former are relatively slight.

Effects of Gas on Vegetation.

It would not appear that vegetation is affected by gas. In the experimental fields or in their immediate neighborhood, the vegetation does not show serious effects from repeated exposure to toxic gases. In the dense forest of the Argonne, which was saturated with gas in the latter stages of the war, the vegetation in the following spring showed no effects whatever.

Effects on Other Sources of Wealth.

The following observations are taken from Professor Zanetti's report, as he is alone in having considered the effects of gas on a country's sources of wealth.

"The effects," he says "would be indirect and would be due either to the paralysing action on the human element, as, for example, the shutting-down of factories through the gassing of the surroundings, so as to render them unapproachable to workmen, or to the action of incendiary material, as, for example, the setting on fire of a grain elevator by dropping incendiary bombs. It is felt, however, that in both cases the question becomes no longer one of purely chemical action and that, although the introduction of certain new incendiary materials has improved this particular branch, the problem has not been essentially changed by the introduction of chemical warfare, as grain elevators can be set on fire with high-explosive bombs and factories rendered useless by shelling them or bombing them from the air. It is to be remarked, however, that the dropping of a few airplane bombs filled with a high-power lachrymatory gas would as effectively shut down a factory, say, a steel mill, for as long as a month without causing any considerable destruction of life or property such as would ensue by long-range shelling or bombing with high explosives.

"In the case of mine pits and galleries, a thorough drenching with a persistent gas, such as mustard gas, or even a simple lachrymatory gas, such as chloracetophenone, would render them unapproachable, except for those duly protected, perhaps for months. The conditions of a mine pit would be ideal for making the gas retain its properties much longer than in the open air, but even under those conditions the gas would eventually be acted on by moisture, even though slowly, and in the course of time would completely disappear. Properly protected disinfecting squads would help along the cleaning of the mine which would resume operations in a far shorter period than would be the case if the galleries and pits had been blown in with high explosives."

To sum up, "no agent is at present known which would produce a chemical destruction of sources of wealth except through its action on the human element connected with the exploitation."

Protection against the Chemical Weapon.

The effects described above are those which would take place if means of protection were not employed. Fortunately, however, the development of the means of protection against noxious substances has kept pace with the extensions of the use of such substances in war. Protection has been obtained by the use of insulating and filtering apparatus. The insulating contrivance consists of a more or less simplified form of diver's apparatus which insulates the wearer from the external atmosphere and supplies him with the oxygen which he needs. In theory, it is a satisfactory solution and one which applies equally to all noxious agents and all degrees of concentration. These contrivances, however, inconvenience the combatants to such an extent that they have been discarded for filter-

ing apparatus. The latter rid the air which is breathed of noxious products by interposing a suitable filter in front of the orifices of the respiratory channel. These filters are either absorbent, porous bodies, dissolving liquids, chemical re-agents or actual strainers.

The various forms of filtering apparatus have proved remarkably effective. Masks taken from men who died from gas poisoning, when subjected to laboratory examination, were found not to be "exhausted"; death had taken place in consequence of the mask having been put on too late, improperly adjusted or removed too soon.

However, as Professor Angeli points out:

"If the concentration exceeds a certain limit, even masks become useless; the men are thus without any means of defence, and, even in those places which were formerly regarded as safest, they cannot escape death."

It is, indeed, essential to the effectiveness of any of these means of protection that those who are to employ them should have them readily at hand and should be trained in their use. Against unprepared and untrained persons the effect of chemical warfare is terrible indeed, as we saw when troops were, at the first use of the chemical arm, suddenly called upon to strive defenceless against a form of attack which, relying on the Hague Convention, they had never contemplated until it was suddenly launched against them. A similar experience would be undergone the first time chemical warfare is employed against civilians.

Protection is still lacking against blistering gases since it would require the wearing of insulated clothing (which would soon prove intolerable), for no filtering clothing exists. The only way, therefore, to obtain protection against blistering gases is immediately to withdraw men who have been subjected to their action, who will at the best remain unfit for military service or other work for several days. Further, no way has been found of providing protection for horses against any poison gas. The large amount of air which they require, their restlessness and the fact that they must have a bit, have made the solution of the problem impossible. Carrier pigeons, on the other hand, live without difficulty in cages protected by cloth impregnated with re-agents.

Such is the present situation, but there is always the fear that the means of protection may one day prove insufficient.

Summary.

The chemical arm, as employed during the last war with increasing intensity and undeniable efficacy, produces the most varied physiological effects. "There are no conceivable limits to its power, its efficacy, and its variety, any more than there are limits to pharmacology or any other branch of chemistry." But, although its very serious effects on unprotected men may be mitigated by adequate protective measures, the problem of the protection of the civil population remains to be solved.

As the harmful substances employed are in constant use in peace time, the chemical arm is at the disposal of any great industrial Power possessing chemical factories, a fact which has led Professors Zanetti and Mayer to draw the following conclusions in their reports.

Professor Zanetti says: "The extreme facility with which these factories can be transformed almost overnight into factories for chemical warfare material introduces an element of fear and distrust towards a chemically powerful neighbour that can easily be understood by those familiar with the possibilities of chemical warfare." "It gives an immense superiority to any Power with hostile intentions," observes Professor Mayer. "An injurious substance studied in secret (and this study may be carried out in any chemical works), and launched unexpectedly against any unprepared population can completely destroy every shadow of resistance."

2. Bacteriological Warfare

In contradistinction to the chemical arm, the "bacteriological" arm has not been employed in war. Apart from all humanitarian considerations, the reasons for this may be found in the contemplation of the effects it might produce were it ever resorted to, as set forth in the statement drawn up for us by Professors Pfeiffer, Bordet, Madsen and Cannon. This statement does not, however, constitute the final word on the subject; for, although the conclusions drawn may be comparatively reassuring for the present, they nevertheless direct attention to the possibilities which the development of bacteriological science may offer in the future, and consequently to the importance of not allowing ourselves to be lulled into any false sense of security.

A priori, the effects of the bacteriological arm can neither be measured nor localised; they would reach the civilian population, would cross frontiers, and might reappear or continue even after the cessation of hostilities. It may be said that this arm would be aimed indirectly against all mankind.

Professors Pfeiffer, Bordet, and Madsen, however, are of opinion that such warfare would have little effect on the actual issue of a contest in view of the protective methods which are available for circumscribing its effects.

The pollution of drinking water by cultures of typhus or cholera germs would be combatted by filtering as already practised in large centres, or by treating the waters of rivers with chlorine. The enemy would have to contaminate by means of aircraft, the filtered water of the reservoirs directly: this would be a difficult operation and its effects would be frustrated by preventive vaccination.

The propagation of plague by pest-infested rats would be as dangerous for the nation employing this method as for its adversary, as rats pass

freely between the lines of both armies. Experience has shown, moreover, that it is possible speedily to check an outbreak of plague. Moreover, the danger of an epidemic of typhus propagated by lice has greatly diminished.

As regards the poisoning of weapons, the experts point out that the germs which could be employed (streptococci or staphylococci, anthrax spores, glanders bacilli, etc.) would not preserve their dangerous properties if they were prepared a long time beforehand and allowed to dry on metallic surfaces. Nor if placed in a projectile would these germs better resist the shock of discharge, the rise of temperature and the violence of an explosion which destroys all life. The only method presenting a certain danger would be that of dropping from airplanes glass globes filled with germs.

Finally, the majority of the experts are of opinion that bacteriology cannot at present produce infective substances capable of destroying a country's livestock and crops. Professor Cannon, however, does not entirely concur in this latter opinion, since he admits the possibility of airplanes disseminating over wide areas parasites capable of ravaging the crops.

In short, the scientists whom we have consulted are of opinion that our present knowledge of hygiene and microbiology would limit the extention of any epidemics which might spread either among combatants or the civil population, and that such epidemics could not have any decisive influence on the issue of hostilities, although the experts do not consider the bacteriological arm as at present capable of paralysing an enemy's defense. But, while they do not regard this double-edged weapon as particularly formidable at the present moment, other opinions are also current which would justify us in keeping carefully in touch with the progress of bacteriology. Professor Bordet refers to the discovery in the court of the German Legation in Bucharest of cultures of glands with requisite instructions for contaminating the Roumanian cavalry.

Possible Use of the Chemical Arm against Civilians.

There is one very important aspect of chemical warfare which we have so far said little in this report, namely, the possible use of poison gas against great cities and other nerve centres of the belligerents. It is difficult to discuss the matter in any detail because so far there has happily been no example of such a thing. Yet it must be admitted that technically there does not appear to be any reason why a poison gas attack from the air or by long range guns used in modern warfare, either on land or sea, might not be very effectively carried out against a great city. There is every reason to believe that in a future war, aircraft would be much more numerous than in the last and they would be able to carry much heavier weights. However reprehensible such an action might be, there would be

nothing technically to prevent them dropping large bombs filled with some heavy poison gas over localities essential to the political or economic life of an enemy country. The gas to be employed would not necessarily be one which only disables human beings for a time, since the object would be to hamper or destroy some continuous activity aimed at by the attack. Mustard gas, for instance, dropped in large quantities would be likely to hang about the cities and slowly penetrate the houses. It is much to be hoped that some means of protecting the civil population from such an attack may be found. But it is right to point out that the problem is a difficult one. To furnish a whole population with gas masks would seem almost impracticable, and methods for collective protection have yet to be proved efficient; yet, short of that, and especially in the absence of any knowledge as to where the attack was to be delivered, no complete protection could be secured. Moreover, heavy poison gases linger, even in the open country for quite a long time. In a city it is difficult to say how long they might remain, and during all that time the danger would continue.

It may be said that such a development of warfare would be too horrible for use and that the conscience of mankind would revolt at it. It may be so, but in view of the fact that in modern wars such as the last one the whole population of a country is more or less directly engaged, it may well be that an unscrupulous belligerent may not see much difference between the use of poison gas against troops in the field and its use against the centres from which those troops draw the sinews of war.

Noting, therefore, on the one hand the ever-increasing and varying machinery of science as applied to warfare, and, on the other, the vital danger to which a nation would expose itself if it were lulled into security by over-confidence in international treaties and conventions, suddenly to find itself defenseless against a new arm, it is, in the opinion of the Commission, essential that all nations should realize to the full the terrible nature of the danger which threatens them.

This thorough report was distributed to the members of the Council, the members of the League and the Delegates at the Assembly. Since then (1924) the yearly reports have been submitted as usual with the usual results — nonactivity. The inner reasons for this inactivity are difficult to assign, but the main stumbling block seems to be the unequal and hence, unfair distribution of chemical producing units. This aspect will be discussed at length in the final chapter.

The League, besides these yearly reports, called together in 1925 a Traffic in Arms Conference which tried to limit the international exchange in arms. Acting on instructions from the War, Navy

and State departments, our American delegates to that conference presented a strong plea for the abolition of poison gas. As the result of our determined stand, a protocol was adopted and signed by the delegates from these nations—Abyssinia, United States, Austria, Belgium, Brazil, British Empire, Canada India, Bulgaria, Chile, Czechoslovakia, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Italy, Japan, Latvia, Lithuania, Luxembourg, The Netherlands (including Netherlands Indies, Surinam, and Curaçao), Nicaragua, Norway, Poland, Portugal, Roumania, Salvador, Kingdom of the Serbs, Croats, and Slovenes, Siam, Spain Sweden, Switzerland, Turkey, Uruguay, Venezuela. To date, only France, Liberia, China, Venezuela have ratified the action of the delegates. The protocol, which is meeting with so little government approbation (mainly because there is so little public opinion consciously active in its support) reads as follows:

Protocol on Abolition of Lethal and Other Gases.

The undersigned Plenipotentiaries, in the names of their respective governments:

Whereas the use in war of asphyxiating, poisonous or other gases and of all analogous liquids, materials or devices has been justly condemned by the general opinion of the civilized world and—

Whereas the prohibition of such use has been declared in Treaties to which the majority of powers of the world are parties and—

To the end that this prohibition shall be universally accepted as a fact of international law, binding alike the conscience and the practice of nations:

Declare—

That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.

The High Contracting Parties will exert every effort to induce other states to accede to the present Protocol. Such accession will be notified to the Government of the French Republic and by the latter to all signatory and acceding powers and will take effect on the date of the notification by the Government of the French Republic, which will at once notify the deposit of such ratification to each of the signatory and acceding Powers.

The instrument of ratification of, and access to the present Protocol will remain deposited in the archives of the Government of the French Republic.

> The present Protocol will come into force for each signatory Power as from the date of deposit of its ratification, and from that moment, each Power will be bound as regards other Powers which have already deposited their ratification.

It is an interesting side light on the procedure of international politics that, although four nations have definitely ratified this protocol, no deposit of such ratification has occurred, and hence, on no nation is the above protocol binding.

When it came time for the Senate of the United States to ratify the action of its delegates, officially instructed to submit and to sponsor in every way the protocol, a sudden aversion to definite action seized the Senators and the resolution for the ratification of the Protocol was withdrawn by Senator Borah to repose quietly in the archives of the Foreign Relations Committee. Although the Senate ratified the 1922 Washington Convention abolishing poison gas, the 1925 convention, rather similarly worded, raised such a storm of opposition that it was withdrawn without definite action.

In the midst of the Senate debate on this resolution, General Pershing wrote on December 10, 1926 to Senator Borah thus, "I cannot think it possible that our country should fail to ratify the protocol which includes this or a similar provision. Scientific research may discover a gas so deadly that it will produce instant death. [As we have noted above, this is now a fact.] To sanction the use of gas in any form would be to open the way for the use of the most deadly gases and the possible poisoning of whole populations of non-combatant men, women and children. The contemplation of such a result is shocking to the senses. It is unthinkable that civilization should deliberately decide upon such a course." On December 13, 1926 the resolution was sent back to the Foreign Relations Committee and no word on poison gas has been mentioned since in the Senate.

And so the Senate, immured in the belief that — as one Senator said—poison gas was just a bit of perfume, refused ratification.

As other nations have been dilatory in their ratifications, the 1928 Assembly of the League added this memorandum to the usual resolution:

> Observing that the Commission has not yet found it possible to submit a single final text as desired by the Assembly, although the Commission agreed that the principle of publicity should extend to government manufactures;

Affirming the urgent necessity for drawing up a convention, which, while placing non-producing and producing countries on an equal footing, would facilitate the ratification of the Convention on the International Trade in Arms and Ammunition and in Implements of War signed at Geneva on June 17, 1925;

Referring to its successive resolutions passed at each of the previous ordinary sessions, beginning with the first session in 1920, in which resolutions it has constantly urged the importance of the problem of the manufacture of arms and the necessity for convening a conference as speedily as possible;

Confirming the fact that connection exists between the general question of the reduction and limitation of armaments and the question of the international trade in arms and also of that of the manufacture of arms and the ammunition and of implements of war:

Requests the Council to make an appeal, at its present session, to the Governments represented on the Special Commission to examine carefully the difference of view revealed during the last session of the Commission and to consider calling another meeting of the Commission before the next Council session, in order that the work of the Commission may be completed as soon as possible and submitted to a special conference for the Reduction and Limitation of Armaments or at an earlier date.

In so far as these efforts of the members of the League of Nations to abolish lethal gas and poison smokes give publicity to the serious situation in regard to the continuance of this form of warfare, these efforts are laudable. That unified, definite action is to be expected from this procedure, is to be hoped for. Step by step, this question must be threshed out until there is evolved a definite workable program for the complete abolition of chemical warfare.

Perhaps regional agreements are one way of attempting the big task. In that direction, two such agreements must be quoted here. At the Conference of Central American Republics held at Washington in 1923, a convention for the limitation of armaments was signed on February 7, 1923 by the Republics of Guatemala, Salvador, Honduras, Nicaragua, and Costa Rica. Article V of this convention reads: "The Contracting Parties consider that the use in warfare of asphyxiating gases, poisonous or similar substances, as well as analogous liquids, materials or devices is contrary to humanitarian principles and to international law, and obligate themselves by the present convention not to use said substances in time of war." This is the second international agreement on the aboli-

tion of poison gas which has been ratified by all signatories and hence, is binding on all signatories.

In May 1923, the Fifth International Conference of American States in session at Santiago, Chile, passed the following resolution:

> Fifth Agreement.
>
> The Fifth International Conference of American States:
>
> Resolves:.....to recommend that the Government reiterate the prohibition of the use of asphyxiating or poisonous gases and all analogous liquids, materials or devices such as are indicated in the Treaty of Washington, dated February 6, 1922.

As this is only a recommendation, no effectual international law is implied. The impossibility and improbability of non-combatant civilian potection from poison gas raids is nowhere more clearly demonstrated than in these instructions which the International Red Cross, concentrating on this very difficult problem of non-combatant protection, has issued in 1928 to its national members for sincere recommendation and adoption.

> First—That the Red Cross will open an international competition with a prize for a design of the most effective type of war gas proof shelter.
>
> Second—That precautions to provide security against gas attacks be taken throughout the territory of all nations, since there is no knowing where an attack will be made.
>
> Third—Advising the creation of shelters of the only invulnerable type thus far produced, which is a hermetically sealable subterranean chamber supplied with chemically produced oxygen or filtered air from a high chimney ventilation operated by a powerful motor. A large number of small shelters was held preferable to shelters of large capacity. These shelters should contain stocks of chemicals for neutralizing the atmosphere, like chloride of lime and permanganate of potash, which, in case of penetration of the shelter by gas could be pulverized by a machine.
>
> Each shelter should contain instructions on how to proceed, printed on gas proof material. Food, water and hospital stocks should be stored in small quantities in gas proof receptacles, the populations being warned that gas contaminating water must be disinfected, boiling being insufficient for that purpose.
>
> Fourth—Fire brigades should be trained to conduct the work of this disinfection, while volunteer corps of nurses and relief workers should be organized in all communities.

Fifth—All new buildings should be constructed with subterranean gas proof shelters separated from the superstructure and from each other by masses of concrete, with stairways leading to them constructed of resistant materials, such as reinforced concrete, the center of which would serve as a chimney for the filtered air.

Sixth—Municipalities should be warned that gas and water pipes must be laid deep under the ground.

Seventh—Each community should be provided with a hermetically sealed van with stores of oxygen for removing the gassed.

Thus, in retrospect, there is no binding, legal international agreement—except for the intrepid action of the Central American Republics—which forbids the use of lethal gas and poisonous smokes to the victor nations in the World War. The conquered nations are chemically disarmed, the victor nations are developing chemical warfare consistently and rapidly.

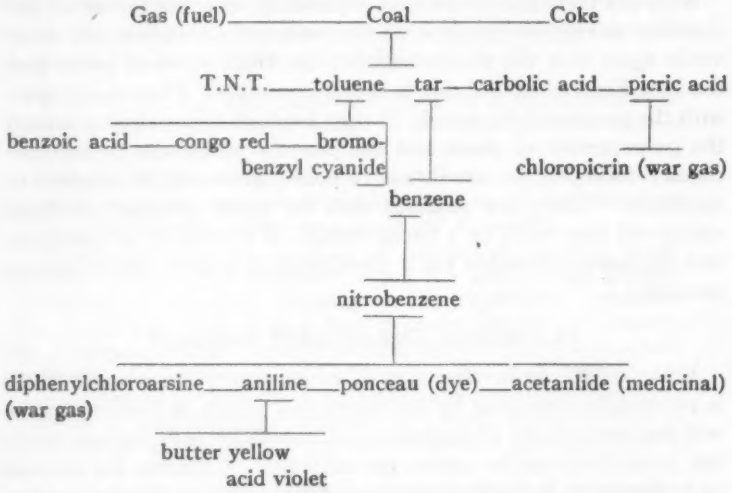
With the facts thus presented impartially, and the review of the situation as regards chemical warfare now fully complete, one must needs agree that the choice between the High Road of peace and the Low Road of destruction is rather imminent. That choice rests with the peoples of the world. If they bend all their energies toward the perpetuation of peace and the peaceful settlement of international difficulties, the use in war of poison gases will be wholly unnecessary. There are peaceful uses for these chemical products which will help build up a better world. If controlled for constructive purposes, chemistry has a great mission to give the awakening peoples.

Is Chemical Disarmament Possible?

What are the peace-time uses of poison gases? In a world which is practically controlled by chemistry and which, as the years pass, will see undreamed of extensions of chemistry into further fields, the peace-time uses for poison gas are legion. Chlorine, the first gas to be liberated, is indispensable as a disinfectant and water purifier. It is the greatest bleaching agent and has many other important uses in the laboratory. Other non-persistent gases, such as chloropicrin, cyanogen chloride and cyanogen bromide can be used for the destruction of the boll weevil and other insects. Hydrocyanic acid gas has been found particularly efficacious in the destruction of insects that ruin the orange and lemon groves in California. Phos-

gene is finding an increasing use in the making of brilliant dyes and acts with equal efficiency in killing rats. Tear gases, such as chloracetophenone, can be used on mobs, escaping jailbirds and other trouble-stirring individuals to temporarily render them *hors de combat* and so, without recourse to gun powder, easily reduce them to order. It is prophesied that every police station, sheriff's office, jail, and penitentiary will be supplied with non-persistent tear gases. The organic chemicals in America, derived from coal are indispensable to fifty major industries. Just to mention a few is an enlightening fact—for instance, varnishes, celluloid, artificial ice plants, fertilizers, tanning industry, paints, lacquers, water-proofing, lubrication, explosives, photography, telegraphy, medicinals, etc.

From coal, dyes, perfumes, and poison gas can be equally easily procured. The following table will explain the close interrelationship graphically.



By the electrolytic decomposition of brine (salt solution), such products as chlorine, caustic soda, soaps, chloride of lime, chloroform, phosgene, chloracetic acid, chloracetophenone, wool green, yellow, cyanogen chloride, crystal violet, etc. are derived. When the air is liquefied, it is readily separated into two main constituents, oxygen and nitrogen. Oxygen is used as a medicinal, as an im-

portant factor in oxyacetylene welding and in the synthesis of phosgene, a war gas. From nitrogen, the fertilizer—calcium cyanimide is derived which in turn yields ammonia Ammonia produces ammonium nitrate, nitric acid, and, in turn, nitrous oxide (an anæsthetic) nitroglycerine, chloropicrin (war gas) and cellulose nitrate (smokeless powder).

The very air we breathe can be transformed into peace-time and war-time products. What hope is there, then, for chemical limitation or chemical disarmament? In the all too brief resumé of the truly enormous field of chemistry and its relation to the equally complicated field of chemical warfare, one all important fact stands clearly forth—the very fundamentals of our civilization—coal, salt, air, etc., can, with well-known chemical reactions, produce poison gases. All discussion of the future of chemical warfare must be predicated upon that fact. What, then, is the future of chemical warfare?

Basing our conclusions on the foregoing facts and revelations as regards the present development of chemical warfare and its future possibilities, it can truthfully and without contradiction be said that if another war between two big chemical-producing nations occurs at any time from now on, warfare on land will use every form of death-dealing or paralyzing chemical agent, put over on the enemy, combatant and non-combatant, irrespective of age, sex or location, to the ultimate end of achieving as wide a destruction as possible in the shortest time. Warfare on sea will witness the same aim, confined to the total destruction of the personnel on the ships by unknown poison gases liberated in every possible way and sucked into the whole ship by the ventilating system. One can envisage battleships, scout cruisers, airplane carriers, submarines, with gassed crews, idly and uselessly floating on the waves, for even the victor fleet (if there will ever be such an anomaly as a victor) would not dare go near the gas-infested vessel. These predictions could be magnified and detailed to inordinate length and the wildest imaginative horrors conjured up to the end that, if reason will not persuade, horrors will. It is an intensely interesting fact that militarists who foresee the future, chemists who know their power, patriots who are pacifists in the fine sense of that term, as represented by such men as Kellogg, Briand, Hughes, Stresemann, Cecil, agree on the truth of these very probable horrors if chemical warfare is persisted in. Such unanimity is, in other lines, unheard of. But each of the three groups interprets the unanimity in varying fashion.

The militarist, basing his logic on the age-old law of force, insists that chemical preparation for the future conflict is the only answer to the threat. The whole chemical industry must be encouraged and, if necessity arises, artificially stimulated so that chemical preparation, down to the last detail, is at the service of the Government. Each nation has its quota of militarists and sincere people who believe that the hope of self-preservation rests in preparedness. To them, there is no such thing as international trust. International agreements are scraps of paper and to be the aggressor nation in the next conflict is their real hope for salvation. Their reliance on the chemical industry is a logical consequence of their stand, for no Government (with the exception of the Soviet Government) produces all its own chemicals. The result of this stand is simply this—in every country there is intense desire to stimulate the chemical industry of that country and chemical combines of great power and strength face each other across the borders. As each new chemical warfare gas is discovered, its secret becomes government property. In a world where fear is the password, these developments are logical. Fear may act as a war preventive to some people. A distinguished American Senator, discussing the new war gases during the futile attempt to have the Geneva protocol banishing the use of poison gas ratified, voiced his opinion in the Senate as to fear, thus: "Suppose we knew that there was such a gas (a lethal gas which could wipe out urban populations) in existence. Do you imagine any country would go to war? Surely not. Fear would deter them. The surest means of preventing war would be the development of such a weapon as that one that would make it infinitely more horrible than it is now."

Fear and chemical preparation are the watchwords of this group. The slogan can be phrased in these words of an eminent exponent—"How much better it is to say to the world that we are going to use chemical warfare to the greatest extent possible in any future struggle. In announcing that we would repeat as always that we are making these preparations only for defense, and who is there who dares question our right to do so?" And as each nation prepares for defense, the old rivalry continues.

The chemist who, because of his intimate knowledge of organic chemistry, predicts that there is no limit to the future possibility of chemical warfare and hence, there is no use in controlling it, argues

from the technical viewpoint only. Technically, he is correct just as he is correct in saying that in some if not in all instances, a chemical factory can be changed within a very short time into a poison gas producing unit. But, when the chemist is pressed to a conclusion of his train of thought, he reaches this suggestion—"Personally, I must confess that I would go very much further than the Government, and seriously consider the provision of gas masks for the population of London and other large towns, and the instruction of school children in their use. If this is not done, there is at least the possibility of disaster of the very first magnitude at an early stage in the next war." (Haldane).

Another chemist, likewise with military experience, Major Lefebure, in an article entitled "Chemical Disarmament" from the *Chemical and Metallurgical Engineering, 1921* gives his views on the subject, differing quite radically from Haldane.

> But how do normal disarmament schemes apply to the chemical type? This type of weapon covers roughly two classes—explosives and the so-called poison gases. Now we must at once correct any false impressions as to the relative importance of these two sections of chemical armament. The recent war has witnessed a gradual change in this matter. Explosives which at the commencement of the war represented nearly 100 per cent of all projectile fillings can no longer claim more than 50 per cent of that capacity. This can be substantiated in many ways. It is sufficient, however, to point to the fact that in the last great German retreat their huge ammunition dumps which we captured contained at least and in many cases more than 50 per cent of shell which were filled not with explosives but with the other type of war chemical commonly called poison gas. There is no doubt that another year of war would have seen this percentage greatly increased.

Convertibility of Dye Plants for Poison Gas Production

Pursuing our analysis, we must face the following question: Is there any essential difference in the disarmament aspect of explosives and the other types of war chemical? They have one common characteristic. This is their peace-time use. This refuses to any disarmament scheme the right to disarm in the simplest fashion—that is, by the total destruction of producing capacity. The world must have for normal development a large producing capacity for explosives and for the other types of chemical armament. This is self-evident for explosives, but may not be so for poison gas. We can readily establish the point,

however, that the poison gas or chemical warfare campaign was initiated, fostered and most thoroughly exploited by Germany of all the belligerents. This country produced practically every ounce of her hundreds of thousands of tons of poison gas in dye plants, in dye factories. The examination of German gas production leaves no doubt whatever that the infinitely flexible, almost instantaneously converted dye plants are a logical means of production of all organic chemical weapons, including explosives.

Facts to be Considered with Chemical Disarmament

We must now stop to lay emphasis on a general principle. There are two methods of disarmament. In the first class you can disarm very simply by destroying all the means of production and preventing their renewed growth. In the second class, because the means of production—the factories—have a peace-time function, you cannot disarm by destruction. How then can you disarm in this case?

There is only one way—it is to insure that no one country possesses a monopoly in the means of production. The brightest and most telling war chemical invention has no value for and no incidence upon warfare unless it can be produced rapidly and in quantity. Production is the key to its war use. Let us examine very briefly, therefore, the world distribution of the means of production for this new type of weapon. The facts are too well known to demand more than a brief reference. Before the war, Germany held the almost absolute monopoly of world organic chemical production. Through this monopoly she launched the poison gas campaign, and for more than two years the Allied reply was relatively feeble. This was not due to Allied lack of invention, but to lack of producing capacity. Production occurred in improvised plants which weakened Allied resources and, most important of all, introduced no essential change in the German monopoly position.

During the war, however, for economic rather than military reasons, dye-producing industries sprang up in France, America and England. Their development was relatively feeble, owing to numerous obvious reasons. They could not make their just demand upon the research forces of the countries concerned. The erection of the plants suffered at the expense of the other great munitions industries which were developing, and in some cases as soon as a plant was erected the dire need of the situation diverted its production from that of dyes to that of explosive and other organic chemicals. From the point of view of our argument this development left the world in the following situation regarding organic chemical producing capacity.

The German dye industry, the source of her war chemical

production, was considerably strengthened. She had a world monopoly before the war, and in every way from the point of view of production, research forces, government support, etc., she was strengthened by the war in her bid for post-war world monopoly. Other countries than Germany were left with promising but relatively feeble organic chemical resources which could not immediately, even under normal commercial conditions, hope to break the German monopoly. In other words, although for most types of armament the pre-war balance in favor of Germany was decreased, yet for this one type of chemical armament the German monopoly was strengthened.

What the German Organic Chemical Monopoly Implies

We are, therefore, left in face of the following situation: For most types of armaments the war has led to a redistribution of producing capacity in the direction of an equilibrium. We can reasonably hope, by materially diminishing this capacity and suitably controlling and inspecting it, to obtain international disarmament; but, in one particular, in chemical warfare, for which the means of production is organic chemical capacity, the final situation is just as remote from any equilibrium as it was before the war. Now we cannot, for the reasons already given, urge the complete destruction of the German producing capacity. On the other hand, disarmament in all other weapons will leave the war importance of chemical warfare greatly enhanced.

The conclusion is obvious. The world must have organic chemical producing capacity, but it cannot tolerate a monopoly of that capacity, especially if that monopoly be held by those who so drastically abused its possession. There must be a redistribution of organic chemical producing capacity throughout the world before we can claim to have even approached disarmament. It would be farcical to proceed with general disarmament schemes and to leave untouched this monopoly in chemical armament. It can, therefore, be claimed without any exaggeration that the chief question before those who wish to see the world on a peace footing is the redistribution of this capacity throughout the world. In other words—and to ignore this issue is dangerous—we must break the German organic chemical monopoly....

We repeat that the crux of all disarmament is the redistribution of organic chemical capacity throughout the world, and that, interpreted into action, this implies the serious reduction of the producing capacity of the German dye monopoly and the international support by the League of Nations, or any other similar bodies which may be established, of the legislative

> measures about to be brought before such countries as America and England for the protection of the growing dye industries, replacing the reduced German dye-producing capacity in those two countries. This is, without any doubt, one of the most important measures now before the world and in addition one of the few measures with regard to which immediate action can be taken toward the stabilization of world peace.

Major Lefebure has been quoted at length to illustrate not only the difficulties in the way of chemical disarmament but also, to demonstrate the mixture of chemical and military suggestions for chemical disarmament. It is wise to bear in mind that redistribution means increased chemical armament by spreading it through all countries. That economic forces will bring about ultimately and naturally this redistribution, seems fairly clear. That this spread will automatically bring chemical disarmament, is an argument difficult to follow. Supported by the example of other disarmament failures, this chemical program will not find many adherents. One point which Major Lefebure made needs more stress. He truly says: "On the other hand, disarmament in all other weapons will leave the war importance of chemical warfare greatly enhanced." Great warships are doomed for, like the mastodon, their size is their undoing. In time, land armament will be reduced and other bulky expensive armaments must go, likewise. As long as a nation has supremacy of the air and a good chemical warfare service, that nation is adequately armed. Therefore, chemical disarmament is the very crux of the whole peace problem and, because of its ramifications and complications deserves separate and constant attention until the solution becomes clear.

The patriot-pacifist gathers these facts on chemical warfare and looks at the problem thus—for thousands of years we have followed the cry of preparedness and more preparedness and it has landed us every time in another war to test out the preparedness. As trust and faith have been built up, after centuries of trial and error, between individuals, so now it must come between nations, slowly, surely, inevitably. What is League of Nations, Locarno pact, Briand-Kellogg peace pact but the first halting gesture toward mutual trust between nations? The statesmen, realizing the probability of chemical warfare if pacific methods should fail, are bending every effort toward peace, real peace. Gradual, slow, sure disarmament leads practically as well as psychologically to peace. A

police force to keep the economic lanes between nations in fair distribution and working condition (without too much jamming due to oil accumulations) will suffice eventually. To the chemist, the instructions go as follows: Devote poison gases to peace-time uses, we will keep the peace.

What of the Future?

We, the people must choose. Do we really want to take the Low Road which leads to fear, distrust, increasing armaments, war, destruction? Or do we really want to take the High Road to mutual trust, decreasing armaments, international cooperation, peace, and real intensive development and improvement?

In particular, we the non-combatants must have a right to say a word or two to those planning the zones of destruction in the next conflict. These "zones" include all living within the area of so-called military operations—which vague term may designate any city, town, or village which has a railroad or factory of any kind. We know that the rules of warfare hold that "the amount of destruction or of suffering which may be caused (in warfare) is immaterial if the result obtained is conceived to be proportionate" and we realize that this idea has been confirmed by most jurists. But even if permissible violence and military utility have been recognized in the past, social sanction questions the right to so extend the zone of military operations that it is only limited by the flight of the airplane or dirigible. Until this epoch-making war weapon was developed there was a definite limitation to the zones of operations, dependent on the range of the guns and the understanding to protect as much as possible, the non-combatant. With each new war invention, the range increased and the danger to non-combatants increased. International agreements have, as the war inventions developed, had to recognize that non-combatant immunity was subordinated to the doctrine of military necessity. The Hague conventions recognized this by their silence on the essential restrictions on effective projectiles. The World War witnessed the great increase in the range of all projectiles. Bombs dropped from enemy airplanes caused 3,408 casualties in England of which 1,413 died. "Among these casualties were very few combatants or workers in war-material plants." (Royse). The object was terrorization and psychological reaction. Allied aerial bombardments on German

towns started in September 1914, but it was only the Armistice which prevented the carrying out of general, widespread destruction by Allied aerial operations of German cities and factories. For non-combatants, it is not reassuring to know that, because of construction errors and lack of well-trained technique, the impossibility of a released bomb hitting the mark was well-known. Dr. Royse in his admirably written book *Aerial Bombardment* says that "Bombs might miss their goal by a thousand yards or more." Hence, "The attacks were not directed altogether against personnel, but the circumstances under which bombing operations were conducted, either at night or in the face of strong ground and air defense, resulted in the actual wiping out of the traditional distinction between civilian populations and combatants." This distinction is non-existent in the future. The present-day bomber, with its bomb-load of 9000 pounds, its crew of six and mountings for ten machine guns, its ability to carry one 4000-pound bomb and two 2000-pound bombs, can and will, in squadron formation rake over any enemy territory, discharging the high explosives first and then leaving the poison gas contents to linger and finish at its own time those remaining. Indiscriminate bombing will widen the area of destruction, and will be as elastic in interpretation as the words "military necessity," which is the only limitation. A British Jurist writes that "it is because of the tremendous moral effect of air attacks that they are at once likely to be carried out against objectives in the heart of an enemy country and to be effective in their purpose of breaking down the enemy's will to resist." For non-combatants, these words of General P. R. C. Groves, Director of Air Operations for the British Air Force are of interest. He states that chemical warfare from the air might cause the loss of millions of lives within a few hours after an attack upon such centers as Paris or London and that it would be impossible to devise means for protecting the population against such an attack. Dr. Royse, after a careful survey of the air forces of the large nations and the international status of such agreements as exist, makes two very serious statements which all, future combatant or non-combatant, must ponder over and then intelligently act on.

The first statement reads—"WHOLESALE DESTRUCTION OF LIVES AND TERRORIZATION OF CIVILIAN POPULATIONS WOULD RESULT FROM CHEMICAL WARFARE IF USED

IN THE FUTURE." Those of the readers who have followed the outline of chemical warfare as presented in this pamphlet, have come to the same conclusion. There is no other.

His second statement, equally serious, based on a thorough historical survey, leads to only one conclusion. "AT NO TIME, AS PREVIOUSLY POINTED OUT, HAS THE EFFECTIVE OPERATION OF VITAL WEAPONS BEEN LIMITED BY INTERNATIONAL REGULATIONS." Again, that insistent choice lies before this generation to make, before it is too late, peaceful settlement of all international disputes and the opportunity for intensive self-development or war and wholesale destruction.

There are many suggestions for chemical limitation and disarmament. All ideas should be followed up, carefully studied in the proper spirit, and applied universally. International Red Cross instructions are all worth while. International agreements may have some effect. But neither may lull the people into a feeling of security against the ever-threatening horror of chemical warfare because ultimate security does not lie there. It only lies with the awakened, intelligent, watchful attitude of us all—the peoples of the world—future combatants and non-combatants. Peace rests with us.

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